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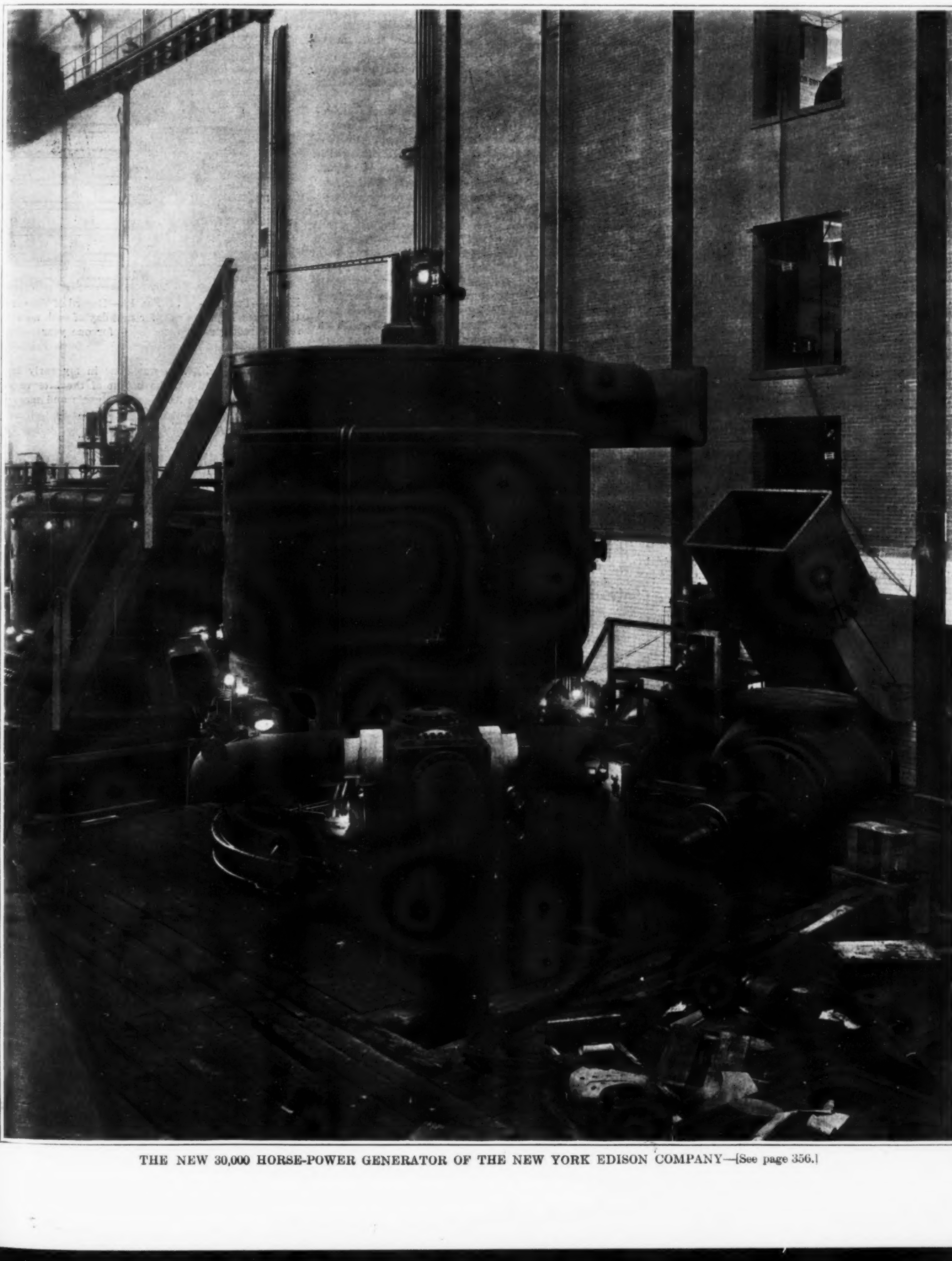


THE NEW 30,000 HORSE-POWER GENERATOR OF THE NEW YORK EDISON COMPANY—[See page 356.]

Radio-Telegraphy—II.*

The Pioneer of the Art Gives An Account of Its Development

By Commendatore G. Marconi

Concluded from Supplement No. 1873, page 339.

The arrangement of aerial adopted at Clifden and Glace Bay is shown in Fig. 7. This system, which is based on the result of tests which I first described before the Royal Society in June, 1906, not only makes it possible to radiate efficiently and receive waves of any desired length, but it also tends to confine the main portion of the radiation to any desired direction. The limitation of transmission to one direction is not very sharply defined, but nevertheless the results obtained are exceedingly useful for practical working.

In a similar manner, by means of these horizontal wires, it is possible to define the bearing or direction of a sending station and also limit the receptivity of the receiver to waves arriving from a given direction.

The commercial working of radio-telegraphy and the widespread application of the system on shore and afloat in nearly all parts of the world have greatly facilitated the marshaling of facts and the observation of effects. Many of these, as I have already stated, still await a satisfactory explanation.

A curious result which I first noticed more than nine years ago in long-distance tests carried out on the steamship "Philadelphia," and which still remains

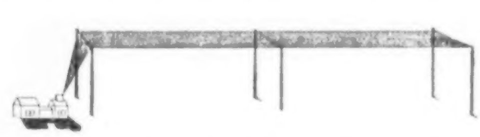


Fig. 7.—The Form of Aerial Used at Clifden and Glace Bay.

an important feature in long-distance space telegraphy, is the detrimental effect produced by daylight on the propagation of electric waves over great distances.

The generally accepted hypothesis of the cause of this absorption of electric waves in sunlight is founded on the belief that the absorption is due to the ionization of the gaseous molecules of the air affected by the ultra-violet light, and as the ultra-violet rays which emanate from the sun are largely absorbed in the upper atmosphere of the earth, it is probable that that portion of the earth's atmosphere which is facing the sun will contain more ions or electrons than that which is in darkness, and therefore, as Sir J. J. Thomson has shown, this illuminated or ionized air will absorb some of the energy of the electric waves.

The wave-length of the oscillations employed has much to do with this interesting phenomenon, long waves being subject to the effect of daylight to a very much lesser degree than are short waves.

Although certain physicists thought some years ago that the daylight effect should be more marked on long waves than on short, the reverse has been my experience; indeed, in some transatlantic experiments, in which waves about 8,000 meters long were used, the energy received by day at the distant receiving station was usually greater than that obtained at night.

Recent observation, however, reveals the interesting fact that the effects vary greatly with the direction in which transmission is taking place, the results obtained when transmitting in a northerly and southerly direction being often altogether different from those observed in the easterly and westerly one.

Research in regard to the changes in the strength of the received radiations which are employed for telegraphy across the Atlantic has been recently greatly facilitated by the use of sensitive galvanometers, by means of which the strength of the received signals can be measured with a fair degree of accuracy.

In regard to moderate power stations such as are employed on ships, and which, in compliance with the International Convention, use wave-lengths of 300 and 600 meters, the distance over which communication can be effected during daytime is generally about the same, whatever the bearing of the ships to each other or to the land stations, while at night interesting and apparently curious results are obtained. Ships more than 1,000 miles away, off the south of Spain or round the coast of Italy, can almost always communicate during the hours of darkness with the post office stations situated on the coasts of England and Ireland, while the same ships when at a similar distance on the Atlantic to the westward of these islands, and on the usual track between England and America, can hardly ever communicate with these shore stations unless by means of specially powerful instruments.

It is also to be noticed that in order to reach ships in the Mediterranean the electric waves have to pass over a large portion of Europe and, in many cases, over the Alps. Such long stretches of land, especially when including very high mountains, constitute, as is well known, an insurmountable barrier to the propagation of short waves during daytime. Although no such obstacles lie between the English and Irish stations and ships in the North Atlantic *en route* for North America, a night transmission of 1,000 miles is there of exceptionally rare occurrence. The same effects generally are noticeable when ships are communicating with stations situated on the Atlantic coast of America.

Although high-power stations are now used for communicating across the Atlantic Ocean, and messages can be sent by day as well as by night, there still exist periods of fairly regular daily occurrence during which the strength of the received signals is at a minimum. Thus in the morning and the evening, when, in consequence of the difference in longitude, daylight or darkness extends only part of the way across the ocean, the received signals are at their weakest. It would almost appear as if electric waves in passing from dark space to illuminated space, and *vice versa*, were reflected and refracted in such manner as to be diverted from the normal path.

Later results, however, seem to indicate that it is unlikely that this difficulty would be experienced in telegraphing over equal distances north and south on about the same meridian, as, in this case, the passage from daylight to darkness would occur more rapidly over the whole distance between the two stations.

Annexed hereto are some diagrams which have been carefully prepared by Mr. H. J. Round. These show the average daily variation of the signals received at Clifden from Glace Bay.

The curves traced on diagram No. 8 show the usual variation in the strength of these transatlantic signals on two wave-lengths, one of 7,000 meters and the other of 5,000 meters.

The strength of the received waves remains, as a rule, steady during daytime.

Shortly after sunset at Clifden they become gradually weaker, and about two hours later they are at their weakest. They then begin to strengthen again, and reach a very high maximum at about the time of sunset at Glace Bay.

They then gradually return to about normal strength, but through the night they are very variable. Shortly before sunrise at Clifden the signals commence to strengthen steadily, and reach another high maximum shortly after sunrise at Clifden. The received energy then steadily decreases again until it reaches a very marked minimum a short time before sunrise at Glace Bay. After that the signals gradually come back to normal day strength.

It can be noticed that, although the shorter wave gives on the average weaker signals, its maximum and minimum variations of strength very sensibly exceed that of the longer wave.

Diagram 9 shows the variations at Clifden during periods of twenty-four hours, commencing at 12 noon, throughout the month of April, 1911, the vertical dotted lines representing sunset and sunrise at Glace Bay and Clifden.

Diagram 10 shows the curve for the first day of each month for one year from May, 1910, to April, 1911.

I carried out a series of tests over longer distances than had ever been previously attempted in September and October of last year between the stations at Clifden and Glace Bay, and a receiving station placed on the Italian steamship "Principessa Mafalda," in the course of a voyage from Italy to the Argentine (Fig. 11).

During these tests the receiving wire was supported

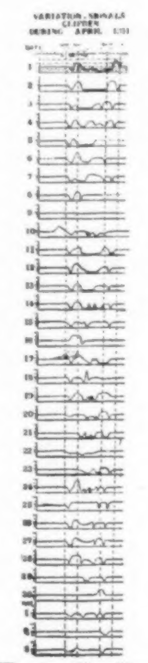


Fig. 9.—The Vertical Lines Represent Sunset and Sunrise.

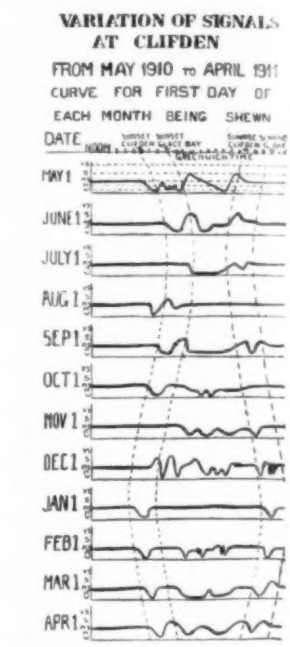


Fig. 10.—Record of the curve for first day of each month for one year

by means of a kite, as was done in my early transatlantic tests of 1901, the height of the kite varying from about 1,000 to 3,000 feet. Signals and messages were obtained without difficulty by day as well as by night up to a distance of 4,000 statute miles from Clifden.

Beyond that distance reception could only be carried out during night time. At Buenos Aires, more than 6,000 miles from Clifden, the night signals from both Clifden and Glace Bay were generally good, but their strength suffered some variations.

It is rather remarkable that the radiations from Clifden should have been detected at Buenos Aires so clearly at night time and not at all during the day, while in Canada the signals coming from Clifden (2,400 miles distant) are no stronger during the night than they are by day.

Further tests have been carried out recently for the Italian government between a station situated at Massaua in East Africa and Coltano in Italy. Considerable interest attached to these experiments in view of the fact that the line connecting the two stations passes over exceedingly dry country and across vast stretches of desert, including parts of Abyssinia, the Sudan, and the Libyan Desert. The distance between the two stations is about 2,600 miles.

The wave-length of the sending station in Africa was too small to allow of transmission being effected during daytime, but the results obtained during the hours of darkness were exceedingly good, the received signals being quite steady and readable.

The improvements introduced at Clifden and Glace Bay have had the result of greatly minimizing the interference to which wireless transmission over long distances was particularly exposed in the early days.

The signals arriving at Clifden from Canada are, as a rule, easily read through any ordinary electrical atmospheric disturbance. This strengthening of the received signals has, moreover, made possible the use of recording instruments which not only give a fixed record of the received messages, but are also capable of being operated at a much higher rate of speed than could ever be obtained by means of an operator reading by sound or sight. The record of the signals is ob-

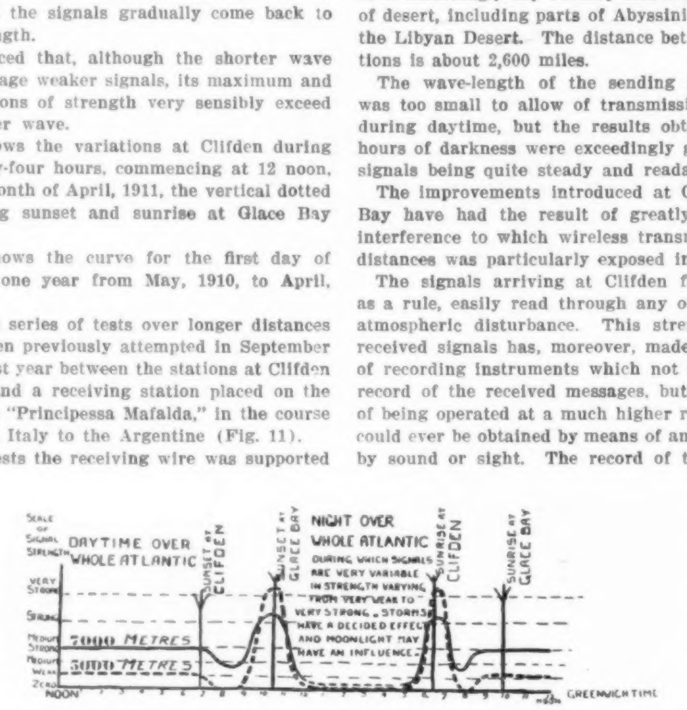


Fig. 8.—Curves Showing Variation of Transatlantic Signal Waves With Time of Day.

* Discourse delivered at the Royal Institution and published in *Nature*.

tained by means of photography in the following manner. A sensitive Einthoven string galvanometer is connected to the magnetic detector or valve receiver, and the deflections of its filament caused by the incoming signals are projected and photographically fixed on a sensitive strip, which is moved along at a suitable speed (Fig. 12). On some of these records it is interesting to note the characteristic marks and signs produced among the signals by natural electric waves or other electrical disturbances of the atmosphere, which, on account of their doubtful origin, have been called "X's."

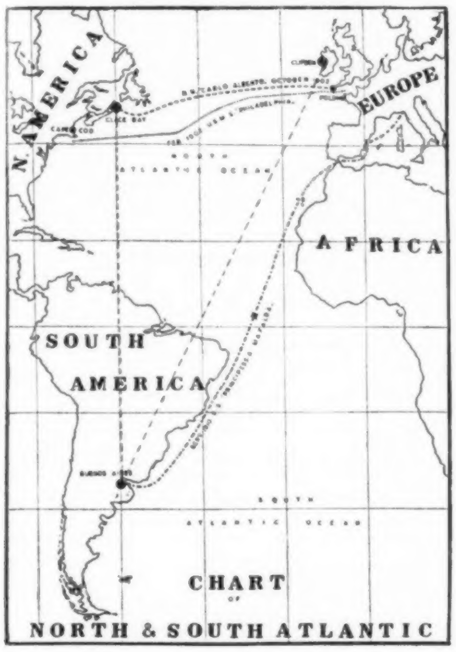


Fig. 11.—Map Showing Plan of Long Distance Tests.

Although the mathematical theory of electric wave propagation through space was worked out by Clerk Maxwell more than fifty years ago, and notwithstanding all the experimental evidence obtained in laboratories concerning the nature of these waves, yet, so far, we understand but incompletely the true fundamental principles concerning the manner of propagation of the waves on which wireless telegraph transmission is based. For example, in the early days of wireless telegraphy it was generally believed that the curvature of the earth would constitute an insurmountable obstacle to the transmission of electric waves between widely separated points. For a considerable time not sufficient account was taken of the probable effect of the earth connection, especially in regard to the transmission of oscillations over long distances.

Physicists seemed to consider for a long time that wireless telegraphy was solely dependent on the effects of free Hertzian radiation through space, and it was years before the probable effect of the conductivity of the earth was considered and discussed.

Lord Rayleigh, in referring to Transatlantic radiotelegraphy, stated in a paper read before the Royal Society in May, 1903, that the results which I had obtained in signalling across the Atlantic suggested a more decided bending or diffraction of the waves round the protuberant earth than had been expected, and, further, said that it imparted a great interest to the theoretical problem. Prof. Fleming in his book on electric-wave telegraphy gives diagrams showing what may be taken to be a diagrammatic representation of the detachment of semi-loops of electric strain from a simple vertical wire (Fig. 13).

As will be seen, these waves do not propagate in the same manner as does free radiation from a classical Hertzian oscillator, but instead glide along the surface of the earth.

Prof. Zenneck has carefully examined the effect of earthed receiving and transmitting aerials, and has endeavored to show mathematically that when the lines of electrical force, constituting a wave front, pass along a surface of low specific inductive capacity—such as the earth—they become inclined forward, their lower ends being retarded by the resistance of the conductor to which they are attached. It therefore would seem that wireless telegraphy as at present practised is, to some extent at least, dependent on the conductivity of the earth, and that the difference in operation across long distances of sea compared to over land is sufficiently explained by the fact that sea water is a much better conductor than is land.

The importance or utility of the earth connection has been sometimes questioned, but in my opinion no practical system of wireless telegraphy exists where the instruments are not in some manner connected to earth. By connection to earth I do not necessarily mean an ordinary metallic connection as used for wire telegraphs. The earth wire may have a condenser in series with it, or it may be connected to what is really equivalent, a capacity area placed close to the surface of the ground. It is now perfectly well known that a condenser, if large enough, does not prevent the passage of high-frequency oscillations, and therefore in this case, when a so-called balancing capacity is used, the antenna is for all practical purposes connected to earth.

I am also of opinion that there is absolutely no foundation in the statement, which has recently been repeated, to the effect that an earth connection is detrimental to good tuning, provided, of course, that the earth is good.

Certainly, in consequence of its resistance, what electricians call a bad earth will damp out the oscillations, and in that way make tuning difficult; but no such effect is noticed when employing an efficient earth connection.

In conclusion, I believe that I am not any too bold when I say that wireless telegraphy is tending to revolutionize our means of communication from place to place on the earth's surface. For example, commercial messages containing a total of 812,200 words were sent and received between Clifden and Glace Bay from May 1, 1910, to the end of April, 1911; wireless telegraphy has already furnished means of communication between ships and the shore where communication was before practically impossible. The fact that a system of imperial wireless telegraphy is to be discussed by the Imperial Conference now holding its meetings in London shows the supremely important position which radio-telegraphy over long distances has assumed in the short space of one decade. Its importance from a commercial, naval and military point of view has increased very greatly during the last few years as a consequence of the innumerable stations which have been erected or are now in course of construction on various coasts, in inland region, and on board ships in all parts of the world. Notwithstanding this multiplicity of stations and their almost constant operation, I can say from practical experience that mutual interference between properly equipped and efficiently tuned instrument has so far been almost entirely absent. Some interference does without doubt take place between ships in consequence of the fact that the two wave-lengths adopted in accordance with the rules laid down by the International Convention are not sufficient for the proper handling of the very large amount of messages transmitted from the ever-increasing number of ships fitted with wireless telegraphy. A considerable advantage will be obtained by the utilization of a third and longer wave to be employed exclusively for communication over long distances.

In regard to the high-power transatlantic stations, the facility with which interference has been prevented has to some extent exceeded my expectations. At a receiving station situated at a distance of only eight miles from the powerful sender at Clifden, during a recent demonstration arranged for the Admiralty, messages could be received from Glace Bay without any interference from Clifden when this latter station was transmitting at full power on a wave-length differing only 25 per cent from the wave radiated from Glace Bay, the ratio between the maximum recorded range of Clifden and 8 miles being in the proportion of 750 to 1.

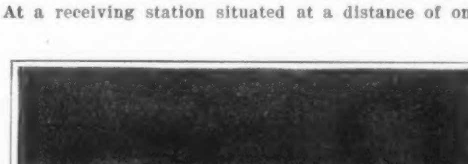


Fig. 12.—Photographic Record of Wireless Signal As Obtained by Means of Einthoven String Galvanometer.

Arrangements are being made permanently to send and receive simultaneously at these stations, which, when completed, will constitute in effect the duplexing of radio-telegraphic communication between Ireland and Canada.

The result which I have last referred to also goes to show that it would be practicable to operate at one time on slightly different wave-lengths a great number of long-distance stations situated in England and Ireland without danger of mutual interference.

The extended use of wireless telegraphy is principally dependent on the ease with which a number of stations can be efficiently worked in the vicinity of each other.

Considering that the wave-lengths at present in use range from 200 to 23,000 feet, and, moreover, that wave-group tuning and directive systems are now available, it is not difficult to foresee that this comparatively new method of communication is destined to fill a position of the greatest importance in facilitating communication throughout the world.

Apart from long-distance work, the practical value of wireless telegraphy may perhaps be divided into two parts, (1) when used for transmission over sea, (2) when used over land.

Many countries, including Italy, Canada, and Spain, have already supplemented their ordinary telegraph systems by wireless telegraphy installations, but some time must pass before this method of communication will be very largely used for inland purposes in Europe generally, owing to the efficient network of landlines already existing, which render further means of communication unnecessary; and therefore it is probable that, at any rate for the present, the main use of radio-telegraphy will be confined to extra-European countries, in some of which climatic conditions and other causes absolutely prohibit the efficient maintenance of landline telegraphy. A proof of this has been afforded by the success which has attended the working of the stations recently erected in Brazil on the Upper Amazon.

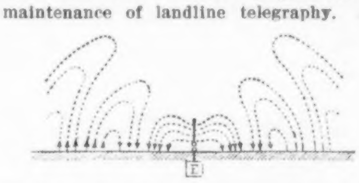


Fig. 13.—Prof. Fleming's Diagram Showing the Influence of the Earth on the Course of a Wave.

By the majority of people the most marvelous side of wireless telegraphy is perhaps considered to be its use at sea. Up to the time of its introduction, ships at any appreciable distance from land had no means of getting in touch with the shore throughout the whole duration of their voyage. But those who now make long sea journeys are no longer cut off from the rest of the world; business men can continue to correspond at reasonable rates with their offices in America and Europe; ordinary social messages can be exchanged between passengers and their friends on shore; a daily newspaper is published on board most of the principal liners giving the chief news of the day. Wireless telegraphy has on more than one occasion proved an invaluable aid to the course of justice, a well known instance of which is the arrest which took place recently through its agency of a notorious criminal when about to land in Canada.

The chief benefit, however, of radio-telegraphy lies in the facility which it affords to ships in distress of communicating their plight to neighboring vessels or coast statons; that it is now considered indispensable for this reason is shown by the fact that several governments have passed a law making a wireless telegraph installation a compulsory part of the equipment of all passenger boats entering their ports.

Amyl Acetate Collodion Varnish

An excellent varnish, acid and alkali proof, and adapted for a great variety of purposes, is made as follows:

Amyl acetate (concentrated), 8 ozs.

Gun cotton (pyroxyline), 350 grs.

When dissolved or nearly so, the solution must be filtered through a tuft of cheesecloth pressed lightly into the neck of a glass funnel. This must be carried out twice, to secure the collodion free from traces of cotton fiber. After filtering it is ready for use.

The above formula, given by Mr. A. J. Jarman, is particularly recommended for covering the transferred image in watch-case photography, according to the process described by him in our issue of October 7th, 1911, no matter whether the image is in carbon or collodion emulsion. The varnish is, however, adapted for innumerable uses, such as putting a protective cover on bright steel, brass, matted silver, etc.; coating walls, woodwork, floors. Fishing lines are made rot-proof by soaking in the varnish. There are many other uses which will occur to the reader.

To Write on Metal

To write inscriptions on metals, take half a pound of nitric acid and one ounce of hydrochloric acid and mix them well together. Cover the part you wish to mark with beeswax, then when cold, with a sharp instrument, write the inscription plainly on the wax clear down to the metal, then apply the mixed acid with a feather, carefully filling each letter. Let it remain from eight to ten minutes, according to the depth required; then wash with water and the job is done.

Starting Up a Thirty Thousand Horse-Power Generator

The Largest of Its Kind in the World

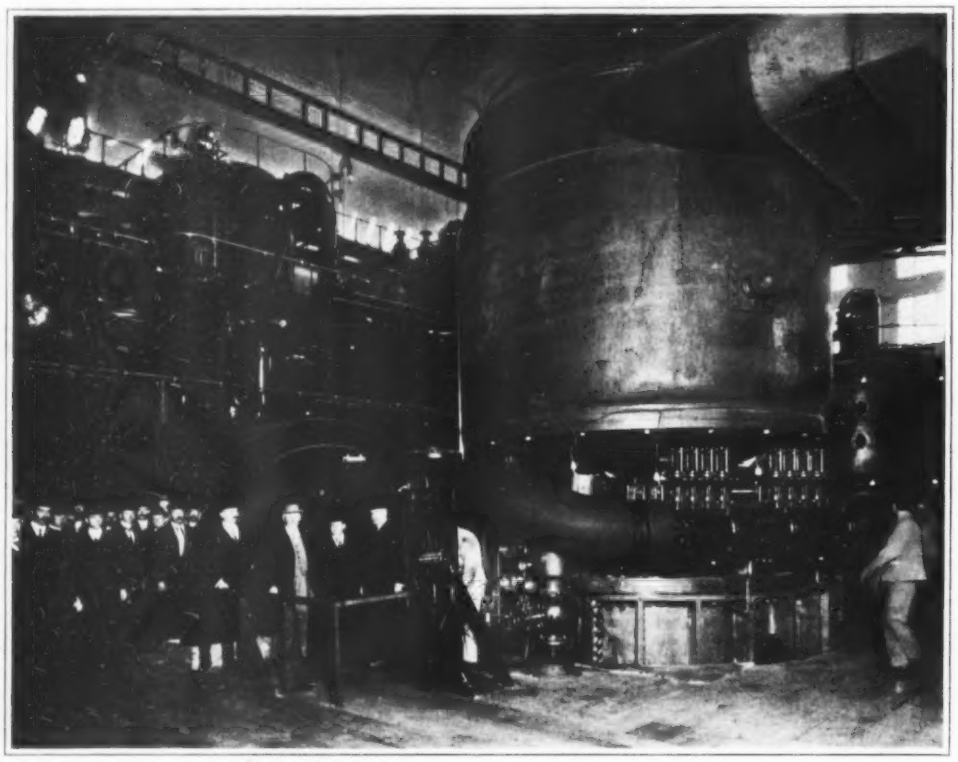
The most powerful machine in the world for the generating of electricity was recently placed in service by Mr. George B. Cortelyou, at the Waterside generating station of the New York Edison Company, 38th, 39th, and 40th Streets and the East River.

Opposite the new machine stood seven huge vertical engines, an older type of generating apparatus, working might and main. At the time appointed for the starting, the guests ranged themselves about the giant turbine. Suddenly the first of the line of vertical engines came to a stop and the turbine got under way. Then one by one the other vertical engines were stopped and their entire "load" transferred to the great turbine.

From a state of idleness the grim monster leaped into roaring activity, assuming the whole work of the seven vertical engines, all of which were brought to a dead stop. Several years ago these vertical engines represented the highest efficiency in current production, and now comes a single machine in comparison with which they are but as toys. The turbine, it must also be remembered, occupies but slightly more floor space than one of the vertical engines.

This great generator has a capacity of 30,000 horse-power, sufficient to supply all the current for the city of Providence, R. I., or any city of about 250,000 population. Alone it would supply a chain of cities such as Albany, Syracuse, and Utica. Its power is equal to that of the largest ocean liner, thirty of the largest express locomotives, or a line of horses six abreast and ten miles long.

The New York Edison Company is the successor to he Edison Electric Illuminating Company, the first corporation ever organized to do incandescent lighting on a permanent basis. The present Edison system is the largest of its kind in the world. The first district station and distributing system were developed by Mr. Thomas A. Edison personally. For many months, day and night, the work had his constant and direct supervision. That which is to-day the best in the generation and distribution of electric current is proceeding on lines which he then discovered and utilized—the direct-connected unit, the underground systems, the meter, in addition to the high-resistance incandescent lamp, the foundation of all.



The upper structure in the alternating current generator. The turbine is partly below the floor.

The side of the old Pearl Street station, a lot 50 x 100 feet, was purchased in May, 1881. The original station was four stories high and when started contained sixteen units, the historical "Jumbos," and supplied current to an underground system of less than fifteen miles in mains and feeders, occupying a territory extending from Wall Street up to Spruce Street, and from Nassau Street over to the East River. The underground system was connected and tested during July, 1882; and September 4th, 1882, at 3 o'clock in the afternoon, the station was placed in permanent operation. It ran continuously with but one break of about three hours in 1883 until the fire of January 2nd, 1890. The interruption to service after the fire did not last more than half a day; thus since 3 o'clock of the afternoon of September 4th, 1882, until the present time, Edison service on Manhattan Island has been fully interrupted only twice, and the aggregate of these interruptions has been less than twelve hours.

The main generators of the Waterside station occupy two city blocks, and have a capacity of 500,000 horse-power. They are the largest of their kind in the world At the present time there are 1,114 miles of mains, feeders, and cables in the underground system.

Through these is supplied current for practically the entire island of Manhattan, containing 21.093 square miles, and the Borough of the Bronx, having 40.65 square miles.

More than 100,000 customers are supplied through 122,000 meters. The installations aggregate 4,341,000 incandescent lamps and 40,200 arc lamps, 263,600 horse-power in motors.

The boilers of the Waterside station are the largest in the world and consume 2,000 tons of coal a day. The bunkers on the roof of the station have a capacity of 30,000 tons. The coal storage yards at Shadyside, N. J., have a capacity of approximately 300,000 tons.

There are thirty-one annex stations, half a dozen district offices, a library, two schools, laboratories, and a number of storerooms. There are one-hundred electric vehicles in the company's service.

A New and Superior Method of Motor Control

Automatic Device for Preventing Unduly Sudden Rise of Current

The acceleration of electric motors has in the past been accomplished by different starting devices, varying from a simple hand operated type to the magnetic switch motor starter. A magnetic switch starter, by the proper operation of magnetically-operated switches, cuts out, step by step, the starting resistance. Such operation is automatic, and in a properly designed apparatus affords thorough protection to the motor and to driven machinery. A magnetic switch motor starter is expensive and complicated, but despite these handicaps it has been widely used in connection with large motors and for automatic control, because of its obvious advantages. Without attempting to enter into a discussion of existing motor starters, it can be stated, without fear of contradiction, that the highly desirable automatic and protective features are secured only at the expense of relatively high cost and complication involving a multiplicity of parts, sensitive relays, and coils wound with wire as fine as thread.

Fig. 1.—Side view.

Fig. 2.—Front view.

A Cleveland firm has developed commercially a magnetic switch which is new in principle and operation. This switch has an operating coil connected in series with the motor to be started, this coil being composed of a few turns of heavy wire of fire-proof insulation. The switch has the remarkable characteristic of inherently and automatically closing its contacts only when the motor current is below a predetermined value. It is in other words a combined magnetic switch and current-limiting relay. If the motor current flowing through this switch exceeds a predetermined value, the switch will lock out, and will not close until the current has been reduced by the speeding up of the motor. A train of these switches cutting out starting resistance step by step provides a method of motor acceleration which is absolutely automatic and protective, and it accomplishes this with apparatus so simple that its expense will not prohibit its application for the starting of any electric motor.

The front and side views of such a magnetic switch are shown in Figs. 1 and 2. The operating coil is inclosed and protected by a cylindrical iron shell mounted on a slate panel; at the top are two copper laminated brushes

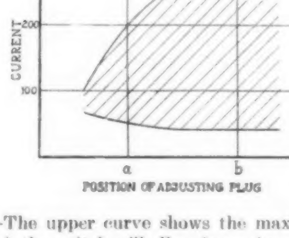


Fig. 3.—The upper curve shows the maximum current which the switch will allow for a given setting of the plug; the lower curve similarly shows the minimum current of the operator's switch.

which, when the switch operates, are short circuited, thereby cutting out a section of resistance. At the bottom of the coil shell a movable plug is provided for adjusting the amount to which current must fall before the switch operates; screwing in this plug will increase the lockout value, and, of course, screwing out the plug will reduce the value of the lockout current.

Fig. 3, exhibits the operating characteristics of the switch in question. Here vertical distances represent current flowing through the operating coil; horizontal distances, positions of the adjusting plug. The shaded area indicates the operating limits of the switch. For example, if the plug be at position, *a*, the switch will lock out at any current above 200 amperes, but will definitely close as soon as the current falls to 200 amperes. Similarly, with the plug at position, *b*, the switch will lock out any current value above 500 amperes, but will operate when the current falls to 300 amperes. The bottom of the shaded area indicates the minimum current at which the switch is operative, although, of course, after the switch has once closed it will remain closed until the current has dropped to practically zero.

It will be apparent from what has been said descriptive of this switch, that its use is peculiarly suitable for motor starters.

A complete line of accessories has also been developed, such, for instance, as would be required for automatic pressure regulation, maintenance of water level in water tanks, etc. The number of accelerating points which any particular starter will develop is one more than the number of accelerating switches used.

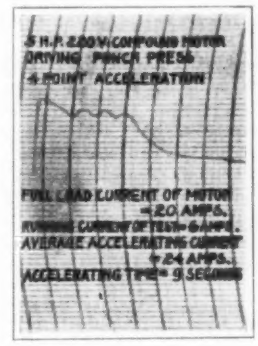


Fig. 4.—Curve showing growth of current at starting with the automatic switch.

The new automatic motor starter inherently provides no-voltage protection, for if the voltage fails, all of the switches at once drop out, inserting all of the starting resistance in series with the motor, and upon the return of voltage the motor is automatically accelerated in the normal method. With such a starter it is merely necessary to close the knife switch to start the motor and to open the knife switch to stop the motor. The acceleration of the motor is entirely automatic, and will be accomplished in the shortest safe time. If the load be light, the switches will close rapidly and bring the motor up to full speed in a short period of time. On the other hand, if the load to be accelerated be large, as, for instance if it be a punch press having a large flywheel, the switches will close much more slowly, and the time required to bring the motor to full speed will be considerably lengthened. In any event, however, the motor is accelerated to full speed in the shortest safe time.

Fig. 4, shows the current, as indicated by a recording ammeter, of a five horse-power motor controlled by an automatic motor starter equipped with three accelerating switches. It can be noticed that the current input during acceleration is uniform and, what is highly important, does not at any time in the operation, exceed a safe value.

Up-to-date Methods of Handling Materials

A Complete System of Electric Traveling Cranes

A RECENTLY completed works at Gary, Ind., affords good material for the man who would study up-to-date methods in modern manufacturing. The plant constructed was absolutely new, so that there was no kind of restriction imposed, such as are always met when remodeling, and neither care nor expense was spared to make the installation the most efficient possible.

There are two main buildings, 700 feet long and 300 feet wide. They are parallel and run north and south, the shipping yard being at the former and the receiving yard at the latter end. The transfer bay, which is one of the important parts of the factory, is situated between the two main shops, and connects them at their central points. This bay is about 100 feet wide, and provides not only an ample floor space for storage, but a convenient communication between the shops.

Practically all material in the plant is handled by electrically driven cranes. The receiving yard at the southern end of the property (750 feet long by 270 feet wide), is covered by three parallel runways. Each runway has two traveling cranes of ten tons capacity. There are in all twenty-five of these cranes. Each is of 90-foot span and is equipped with two 5-ton hoists. Material is conveyed direct from the railway tracks, which run on both sides and through the center of the property to large wooden skids.

The shipping yard at the opposite end of the plant is a trifle smaller than the receiving yard. It contains an 80-foot runway on which four 30-ton Cleveland cranes are operated, and also a shorter runway which is in front of the forge and machine shops, and supports a 30-ton Cleveland crane of 80-foot span. This yard is provided with I-beam skids on concrete.

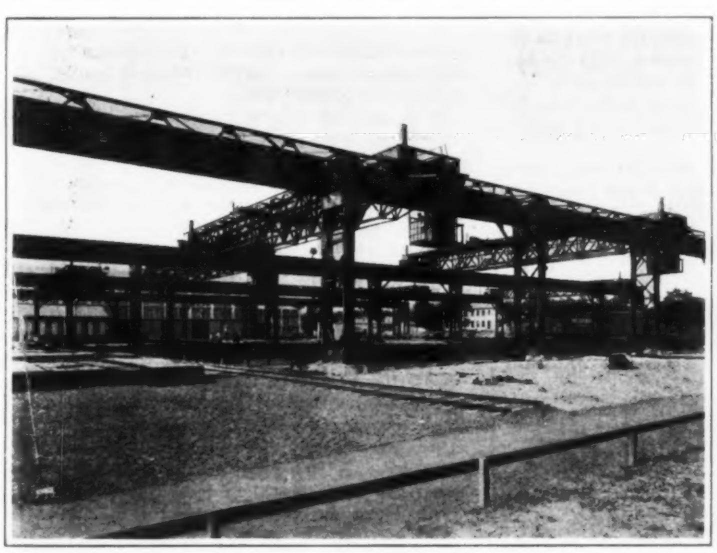
The rivet shop contains a 10-ton traveling crane of 40-foot span. The crane contains a large receptacle, and when this is filled it moves to the proper bin and unloads its cargo.

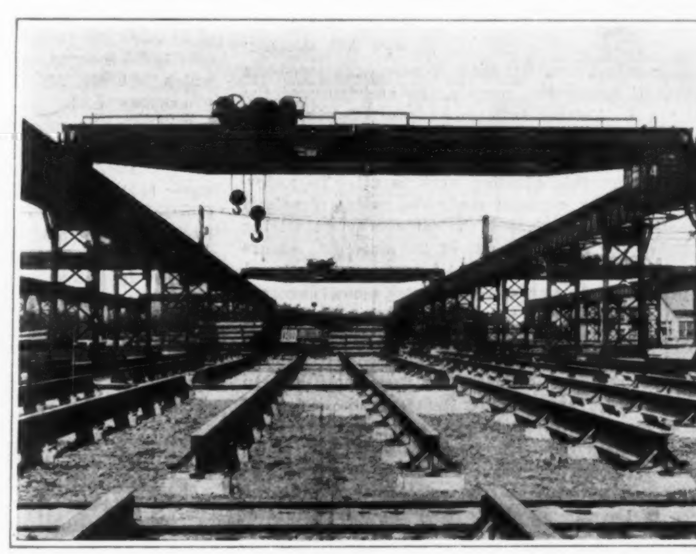
Gantry cranes on 12-foot tracks run over the hydraulic riveters in the punch and sheering departments. The cranes working over the 100-ton riveters, have 40 tons capacity, while those which handle the 60-ton riveters need to be only of 15 ton capacity. The finishing department contains four reaming gantries.

A 10-ton Cleveland traveling crane of 40-foot span is installed for the special purpose of moving machinery. In the forge shop a 5-ton 60-foot span traveling crane has displaced the old-type hand hoists. The main bay of the machine shop contains a Cleveland 25-ton crane with 60-foot span. Working over the machine tools are 2-ton revolving traveling jib cranes, made and designed by the American Bridge Company, the owners of the plant here described. These small cranes and the large one all work in co-operation.

Speaking of co-operation, the term is usually applied to the men, as in the case of the fire department, in politics, the police department, etc., but for co-operation of machines let us commend the ingenious brain that devised the system of the assembling hoists. The hoists operate on 20-foot runways, which are parallel and extend not only through the shops, but also to the transfer bay. The hoist tracks are so closely and accurately placed that loads may reach any part of the shop or bay whatsoever, which means that a hoist may be transferred from one runway to another. The northern end of each building is additionally equipped with two 40-ton 40-foot span Cleveland traveling cranes, and the side bays are taken care of by 10-ton cranes of similar type and span.

Throughout the entire plant there is an industrial railway system of 3-foot gage. In the important departments there are four tracks and all grades have been carefully provided for.





VIEWS OF THE GREAT ELECTRIC TRAVELING CRANES AT GARY, INDIANA.

Methods of the Ancients for Finding Springs

THE manner of finding springs of drinking water described by the old Roman author and military engineer, Vitruvius Pollio, who worked and wrote in the reigns of Julius Cæsar and Augustus, is of seasonable interest in view of the numerous discussions of the divine rod question which have been published in the last few years. In the first chapter of the eighth book of his work "De architectura," dedicated to Augustus, he says that when no springs are visible, the hidden strata are to be found by the investigator lying face downward on the ground before sun-down, resting the chin on the ground, so that the eyes are kept directed along the plane of the earth's surface. Looking in all directions along the surface, some spot may be found where a light vapor arises from the earth; this point is selected for sinking the well, for where there is no such vapor there can be no subterranean spring.

After speaking further concerning the quality of the water, and warning his readers not to be too sure of the presence of springs in low-lying damp places, as these may be caused by a trough-like formation, which holds the surface water a long time, he says that if the first method recommended fails to find water, there should be dug a hole about five feet long, wide and deep, in which a metal vessel is to be set; the hole is then to be covered with reeds and earth. If on uncovering the hole the next day the metal vessel is so moist, that the water drops therefrom, there is water below.

Another test consists in placing an unburned piece of pottery in the hole covering the same as before; if on uncovering the hole, the potsherd is damp or perhaps even fallen apart from the moisture, water is present.

Further on he says: If in such a place a fire be made and the earth which is thereby heated gives off vapor, there is water below.

Traveling At High Speeds—I.*

By Prof. Hele-Shaw

From what few and somewhat uncertain records we have of the achievements of man in running in the ancient sports, it does not seem there is very much difference between his powers then and in modern times. As to modern times, we find that for the short distance of 100 yards, and for the longer distance of a mile, the records of twenty-five years ago still stand, notwithstanding the strenuous efforts made to improve upon them on many scores of occasions each subsequent year. Thus we have for the former the record of E. Donnovan in 1886, 21.3 miles an hour, and in the same year the record of W. G. George for the mile, 14.2 miles an hour, which have never been beaten; while for one distance, that of 200 yards, the record of G. Seward in 1847, or sixty-four years ago, still stands. In fact, a study of all the records of twenty-five distances shows that several of them remain unbroken after comparatively long periods, viz., from a quarter to half a century.

Thus, so far as his own unaided powers of locomotion are concerned, man may be considered, for all practical purposes, to have reached long ago the limit of speed possibility. From earliest times, however, he has brought the muscular effort of other animals into his service, and has devoted his intellect towards improving their speed for his own uses. In Fig. 1 are graphically recorded the speeds of all the Derby winners from the year 1856, i. e., for more than half a century. The average speed, which may be taken as somewhere above 30 miles an hour has doubtless slightly increased, but it will be seen from the dotted line which has been drawn at the top of the maximum speeds what comparatively little increase has been obtained for an expenditure of the many millions represented directly and indirectly in the training and breeding of these horses, and it may be reasonably assumed that here again the limit has been reached for the fleetest animal, by the aid of which man can increase his speed of locomotion by using muscular power other than his own.

What, then, are the physical reasons for this limitation? It is not due to the chief cause which we shall see later puts a practical limit to very high speeds in mechanical locomotion, namely, the resistance of the atmosphere. Neither is it due to the effective work done in movement, since with a body moving along a level plain, i. e., at a constant distance from the earth's center, this effective work is nil. To understand the matter we must study the nature of animal locomotion. The surface of the earth is rough, sliding along it being obviously out of the question; nature has made provision for animal movement as follows: one part of the body first rests on the ground, another part supported by this is advanced, being raised clear of the ground, to rest in turn upon the ground and servè in turn as a support, so that the part behind may be raised and advanced to a fresh position. In man and other animals the feet form the points of support for this process; but the same method of locomotion is employed by creatures without feet, which have to crawl or glide, such as snakes or worms.

This process, whether with animals or reptiles, involves in the raising of the body an expenditure of work which is not recovered, and further an expenditure of work in stopping and starting some portion of the body in its movements. There is a third cause of loss, namely, the energy involved in swinging the legs. About thirty years ago the distinguished French professor, Marey, actually investigated the loss involved from each of these three causes. The number of steps per minute increases until a pace is reached when it becomes painful to walk faster, and at about ninety steps per minute the gait changes to a run, that is to say, a springing action takes place, the hind foot leaving the ground before the front is put down upon it.

The length of stride at first increases with the pace, and afterward begins to fall off before the walking breaks into a run. The reason why a man or an animal changes his pace at this point is obvious, and it is because a faster speed is possible with a less effort. As the speed of running is increased the total effort becomes greater, but the three elements shown on the diagram are differently divided; the rise and fall element is less, but the work done in swinging the legs is more, while the chief element, in the muscular effort expended, is the loss of energy involved in stopping and starting as each spring reaches a maximum. Similar causes operate in the natural locomotion of other animals which move on legs.

We therefore now know that the limit of speed is controlled by two factors:

*Paper read at the Royal Institution on May 4, 1911 and published in *Nature*.

(1) Physical endurance, owing to the expenditure of work occurring at an increasing rate as the speed is increased.

(2) The physical impossibility of giving a reciprocating movement to the legs quicker than a certain limited period of time.

I have prepared a chart, Fig. 2, which shows the maximum recorded velocities of man's progression in walking and running. The speeds are set up as vertical ordinates, and the abscissæ represent the distances over which the respective speeds were maintained. It will be seen that the maximum speed of walking is about 9 miles an hour for a short distance, but when

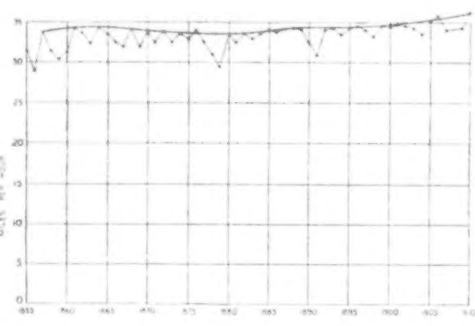


Fig. 1.—Derby Winner for 55 years.

the long distance of 100 miles is covered, the quickest rate recorded falls to 5½ miles an hour. For running, the quickest speed which I have mentioned, viz., 21.3 miles an hour for 100 yards, falls to 7½ miles an hour as the average speed for a distance of 100 miles.

We do not know the speed of the original historical run from Marathon to Athens, but we do know that J. Hayes ran the modern Marathon from Windsor Castle to the Stadium at Shepherd's Bush, a distance of 26 miles 385 yards in (to be exact) 2 hours 55 minutes 18 2-5 seconds, or at the rate of 9 miles per hour, which, you see, fits very well on our curve.

We may notice in passing that in walking fast and starting to run the arms swing in time with the opposite leg.

What man can do by his muscular effort in the water is shown by the small curve in the corner. The greatest distance shown (Fig. 2) is about 21 miles by Captain Webb at about 1 mile per hour, although for a short distance it will be seen that a man can swim at about 4 miles per hour. I do not put in flying, because man has not yet flown by his own muscular effort, and flying men to-day are using engines of from 20 horse-power to 100 horse-power, i. e., from

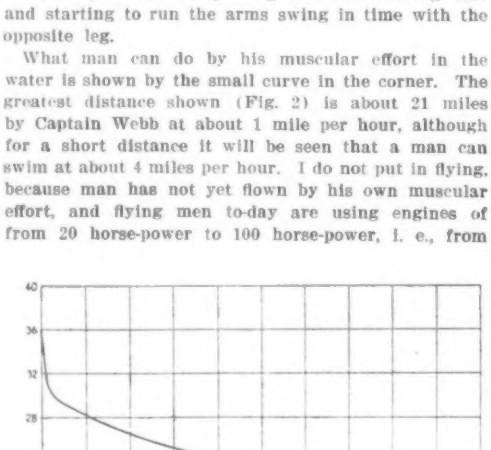


Fig. 2—Speed record for human muscular effort.

200 to 1,000 *man-power*. Gliding *per se* is no more than falling through the air (more or less) gradually, as in a parachute.

Before proceeding to see what man has done to increase his powers of purely muscular locomotion by means of mechanical devices we will study the details of locomotion in the other animals. We are able to do this by the method of Mr. Muybridge, since developed in the invention of the kinematograph.

Take, first, the galloping horse. By studying the various phases in the action of a horse, we find that the animal is not only able to attain its high speed by its length of stride, but by doing what man cannot do to the same extent—drawing up its body and in springing forward, using alternately its fore and hind feet, so as to get a stride which no two-footed creature could attain on the level ground. I may point out that the kangaroo, though using only two legs, makes effective use of its tail in the spring. The horse springs clear of the ground off its forefeet, only it uses both its fore and hind legs as the spokes of a wheel on which it rolls when walking (exactly as man does), though it rolls and springs alternately in galloping.

Turning next to other animals, it is interesting to observe that a greyhound gets its high speed in proportion to its size owing to the great flexibility of its long body, which enables it to draw its hind legs forward each time for the next bound, and also bound forward both from its fore and hind legs. The other animals in galloping have each the same general kind of movement, although the deer, curiously enough, only bounds from its hind legs, and differs in this respect from the horse; and also it will be noticed the want of flexibility in the body of an animal may be one of the causes of its relatively slow speed. But whether it be man, horse, dog, or any other animal, the same characteristic is found, namely, that locomotion, apart from the bounding action, takes place by a sort of rolling action on the ground. The idea which had persisted since the delineation of horses in Assyrian and Egyptian pictures, that both the fore or both the hind legs are put on the ground simultaneously, is thus exploded. As Mr. Muybridge truly said: "When during a gallop, the fore and hind legs are severally and consecutively thrust forward and backward to their fullest extent, their comparative inaction may create in the mind of the careless observer an impression of indistinct outlines; these successive appearances were probably combined by the earliest sculptors and painters, and with grotesque exaggeration adopted as the solitary position to illustrate great speed." As a matter of fact, each leg in turn, as it rests on the ground, stops for a moment just as much as in the forward position, and if you watch a dog galloping you can see quite clearly the rolling stroke action I have mentioned.

With the above facts in mind, we can understand exactly the limitations to animal locomotion. In the words of Mr. Muybridge: "When the body of an animal is being carried forward with uniform motion, the limbs in their relation to it have alternately a progressive and a retrogressive action, their various portions accelerating in comparative speeds and repose as they extend downward to the feet, which are subjected to successive changes from a condition of absolute rest, to a varying increased velocity in comparison with that of the body." Hence all animal locomotion absolutely lacks that continuity of movement, the production of which we shall see is the distinguishing feature and the direct cause of the high speeds attained in mechanical locomotion.

The exchange of the intermittent movement of nature for one having the desired continuity of movement has been effected by means of what is possibly the greatest and yet the simplest of all human inventions, namely, the wheel. The wheel was made and used probably thousands of years before man learned to replace muscular effort by that of steam and the other forces of nature, the origin of the wheel being absolutely lost in antiquity.

The wheel overcomes the defect of animal locomotion, giving a rotary and continuous movement instead of a reciprocating and variable one. At one and the same time the wheel, therefore, does away with the three causes of loss shown in the diagram as occurring with animal locomotion. The mere use of the wheel has enabled man himself, by his own muscular effort, enormously to increase his individual power of locomotion. The top curve on Fig. 2 shows, in comparison with the other curves of walking and running, his unpaced records on a bicycle, in using which it will be realized that all three causes of loss which occur in running and walking are obviated. You will notice a similar difference in speed as the distance varies to that which is made evident in the curves for walking and running. For the distance of 100 miles the average speed is thus only 21 miles an hour, while that for ¼ mile is more than 35 miles an hour. In view of the results shown by the curve, it is not surprising that the bicycle has entered largely into the conditions of modern life. I am not able to give you any exact figures of the quantity of bicycles turned out each year in this country, but I can tell you that in the post office alone there are now 12,000 bicycles employed, and their number is always on the increase;

the distance covered on them by men and boys in the year is more than 120,000,000 miles.

I have not dealt with *paced* bicycle records, as such are not the result of muscular effort, but of being pulled along by the current of wind which follows up the pacing machine such as occurs when a man on a "push" bicycle is paced by a motor vehicle. In a record first set up in America for 60 miles an hour on a bicycle, a man was paced by a locomotive engine running at 60 miles an hour along a special track; the rider was nearly killed when he tried to drop behind, owing to the whirlwind which was being dragged along by the engine; ultimately his life was saved by his being lifted bodily off his bicycle on to the locomotive. There is no record as to what became of the bicycle.

Curiously enough, records for ice skating and roller skating are almost the same, and far below that on the bicycle, which I think proves distinctly that the reciprocating movement of the limbs limits man's powers, whether he is sliding on the ice or using wheels as with roller skates. This is so, notwithstanding that he carries along with him when on a bicycle the extra weight of the bicycle, but the reciprocating movement of his legs is so slow, owing to the gearing up of the driving wheel, as to give him the material advantage shown by the respective curves. Further, in skating, there is no doubt that the movement of his limbs entails a certain amount of rising and falling, as well as reciprocating motion and consequent loss which occurs in running.

Now, in theory, the wheel is perfect, and in the case of a perfectly hard, circular wheel, rolling on a perfectly hard track, there should be no resistance. But it is just in this direction that the wheel has defects unknown to nature's methods, since men and animals move upon the ankle joint in a quite superior way to the rolling of an ordinary wheel. In passing I may remark that the more man improves the roads, and the higher his standard of locomotion becomes, the more will he feel the need of a mechanical walking machine (it will be a *walking* machine, though possibly moving at 20 miles per hour) to progress over parts of the earth where roads do not exist, or are still in an evil condition. The better his mechanical appliances for producing such a walking machine, the sooner will this come about, as this is really a vital factor in the solution of the problem. No wheel, however, is quite hard and round, and no road is quite hard and smooth, and there is always an arc of contact, more or less appreciable, which causes a loss, since rubbing takes place instead of true rolling. When the wheel meets obstacles and is deflected from its course, exactly the same kind of loss occurs as with a man in walking.

Thus there are two ways in which the wheel can be improved:

(1) Is by perfecting the wheel and hardening the track—and that is the secret of the development of the railway system.

(2) The other is by causing the obstacle to be absorbed in the tire of the wheel—that is the real secret of the success of the pneumatic tire.

To-day we can replace the muscular energy of man by almost unlimited mechanical power, and Fig. 3 is a comparative speed chart which I have prepared and which indicates the enormous advance in the

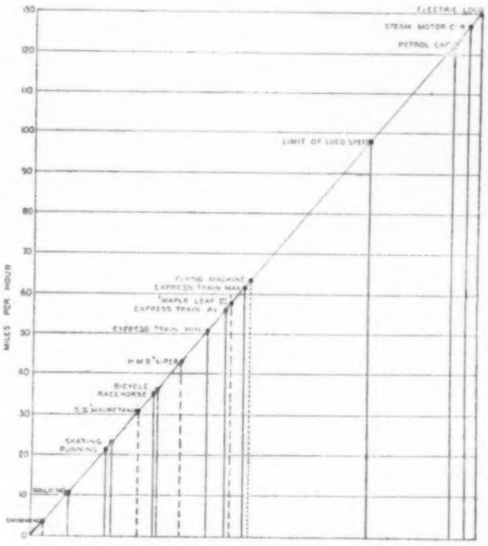


Fig. 3.—Graphical table of maximum speeds.

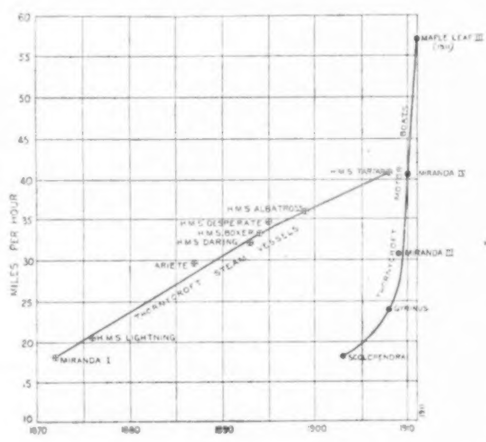


Fig. 4.—Speed records for Thornycroft Warships and Motor boats.

speed record which has been made over the best unaided muscular efforts of any animal. It is curious to see that the highest speed ever attained on a railway is closely approached by that obtained with motor vehicles. The records for the latter are as follows:

A Darracq car of 200 horse-power has done 122½ miles an hour for 2 miles. A Fiat car, driven by Nazarro at Brooklands, 126 miles an hour. A Stanley steam car, 127 miles an hour, and a Benz car has done 127½ miles an hour.*

The maximum recorded speeds of a railway were on the experimental line of Messrs. Siemens, on the Berlin-Zossen High Speed Railway, where a speed of rather more than 130 miles an hour was attained. The electric current employed was 10,000 volts, 400 horse-power motors being used. On the Marienfel-Zossen experimental line, the speed attained with 250 horse-power was apparently rather less, though in that locomotive four motors were employed, the current being, as in the other case, 10,000 volts.

The foregoing are the record speeds so far obtained of mechanical locomotion, and it will be interesting to see what are the record speeds attained in the other elements. Until the other day, as Mr. Parsons told us in his lecture, the speed on water which has never been exceeded was that of the ill-fated turbine boats, "Viper" and "Cobra," of about 43 miles an hour. The ship which at present holds the record for speed is the torpedo destroyer "Tartar," built by Messrs. John Thornycroft, this, under Admiralty tests, giving a speed of 41 miles an hour.

The diagram, Fig. 4, shows in an interesting manner what the progress in speed has been for this class of boats during the last few years, and may be taken as typical, and about which curves Sir John Thornycroft writes as follows:

"I do not think the curve would be materially altered if vessels of other builders were brought in, although there would naturally be more points on it."

I am able, however, to give you the results to-night of something which has altogether put in the shade even the speeds of the two first-mentioned boats. This has been attained by a boat which, though corresponding in some respects with previous hydroplane boats, has been designed by Sir John Thornycroft to possess a certain amount of seaworthiness. The rate of progress in the increasing speeds in this class of boat is shown on a separate curve, Fig. 4, from which you will see that the celebrated "Miranda" held as a hydroplane the record with the "Tartar" for speed, the "Ursula" also holding the record of about the same speed as a motor-boat.†

(To be continued.)

Stage Jewelry Alloy.—An alloy of 19 parts of lead and 29 parts of tin (the metals must be very pure) possesses a very brilliant diamond like brightness, and is used in making stage jewelry. For this purpose, the alloy is first produced by melting the metals and pouring them together and after a poured sample shows the proper consistency, the casting of the ornaments is proceeded with.

* This record has since been beaten by Bob Burman, who covered the mile at a speed of 141.73 miles per hour with a 200-horse-power Benz gasoline racing car on April 23, 1911.

† The highest speed attained by a motor boat is 45.81 miles per hour, on a one-mile trial run by the "Dixie," which carries 500 horse-power. In the International Cup Race (30 miles), this boat made an average speed of 40.49 miles per hour.—Ed.

The Cost of Power from the Sun and from Coal*

A Comparative Estimate

By Frank Shuman

It is of interest to know what the comparative cost of sun power and coal power is, in the tropics, as far as our present knowledge and present developments go.

The sun power plant of course, must be a condensing plant, as steam above atmospheric pressure cannot practically be used. I have assumed in estimating, that the 100-horse-power sun plant mentioned, is to be complete in every detail, covering also the pumps necessary for using the power generated for irrigating purposes. In order to put the coal plant on the same basis, I have assumed a simple form of modern compound condensing engine with good coal economy for such small powers, viz., three pounds of coal per brake-horse-power. This coal plant is also to be fully equipped with all condensing apparatus and pump for utilizing the power for irrigating purposes. They are both to be based on running eight hours per day. Both plants to be manufactured in Philadelphia in portable shape, and erected at some fairly accessible point in the tropics.

This comparison would then stand as follows:*

Cost of operating 100-H.-P. sun plant for one year.

Original cost of plant, $20,000.

Interest on $20,000 at 5 per cent	$1,000
Wear and tear at 5 per cent per annum	1,000
One engineer, 350 days at $5	1,750
Total	$3,750

Cost of operating 100-H.-P. coal plant for one year.

Original cost, $10,000 complete.

Interest at 5 per cent	$500
Wear and tear at 5 per cent per annum	500
One engineer, 350 days at $5	1,750
Total	$2,750

The above comparison shows it would cost $1,000 per year more to operate a sun plant than a coal plant and do the same amount of work. All minor expenses, such as lubrication, etc., are the same in both plants.

The 100-horse-power coal plant based on a coal consumption of three pounds per brake-horse-power, would burn during the year, 375 long tons of coal. This when divided into the $1,000, which the sun power plant costs above the coal plant, would bring the cost of this coal to $2.66 per ton; showing that wherever coal can be obtained at a cost of $2.66 per ton, both the sun plant and the coal plant would be equal competitors.

The great savings which will occur through the use of sun power plants, consist in the fact that through vast regions of the tropics, coal varies from $5 per ton *at the most accessible seaports*, to as high as $30 at inaccessible points. As a general average it might well be assumed that coal throughout great areas of the tropics will average $15 per ton; *and here lies the great field for sun power.*

Coal in the Chilean nitrate districts, for instance, I have been officially informed, costs $14.60 per ton, and there is room for 100,000 horse-power in this region alone.

* The estimate here given corresponds to a sun power plant such as described in the issue of September 30th, 1911, of the Scientific American.

Developement of Photographic Images After Fixing

Neuhauss has shown that latent photographic images upon silver bromide plates can be developed after fixing in hypo. This method, however, can only be employed when the plates have been exposed twenty times the normal amount. It is now reported in *Comptes Rendus* by Lumière and Seyewetz that by using a fixing bath consisting of a 2 per cent solution of hypo it is possible to fix before developing, with an exposure only four times the normal in the case of slow plates and six times the normal for rapid plates. The double sulphite of silver and sodium is found to yield the best results as developer.

The Deperdussin Monoplane

Racing and Other Models

By John Jay Ide

The monoplane designed by M. Adolf Deperdussin was shown to the public for the first time at the last Salon de l'Aeronautique at Paris. The machine exhibited at the Grand Palais had a six-bladed tractor screw but this feature was later discarded in favor of a tractor of the standard two-bladed type.

The scale drawings which accompany this article refer to the racing type, which has been the most in the public eye. In addition to this model, however, four other types are manufactured. They are as follows:

I. One Seater.
- (*a*). 40 horse-power Clerget $4,400
- (*b*). 50 horse-power Gnome 4,800

II. Two Seater. Narrow fuselage.
- (*a*). 50 horse-power Gnome 5,200
- (*b*). 70 horse-power Gnome 5,800

III. Two seater. Medium fuselage.
- (*a*). 70 horse-power Daimler 5,600
- (*b*). 70 horse-power Gnome 6,200
- (*c*). 100 horse-power Gnome 7,600

IV. Three seater. Wide fuselage.
- (*a*). 70 horse-power Gnome 6,600
- (*b*). 100 horse-power Gnome 8,000

The prices are for delivery at the factory in France. The photograph of the machine in flight represents Type I (*b*), as does the front view, while the head pieces show Type II (*a*). The Deperdussin forms a third member of the class which has hitherto been composed of the Antoinette and the Hanriot. The fuselage is completely inclosed and square in section except at the front, where a semi-cylindrical well affords increased accommodation for the pilot, who, however, as in the Antoinette, sits high up in the machine. The shallow fuselage is pretty to the eye, but it gives little protection to the pilot, who is the cause of extra head resistance. The most satisfactory body so far designed is undoubtedly that of the Nieuport, which gives perfect protection to the pilot and at the same time has the minimum of head resistance on account of its streamline form.

The combined oil and gasoline tank is mounted in front of the pilot, and gages are fitted, so that he is constantly acquainted with the state of his fuel supply. A small reserve tank is placed under the seat. In the racing model the motor is either a 50 or 70 horse-power Gnome. Over it is arranged an aluminium shield to prevent the oil spray from the exhaust reaching the pilot.

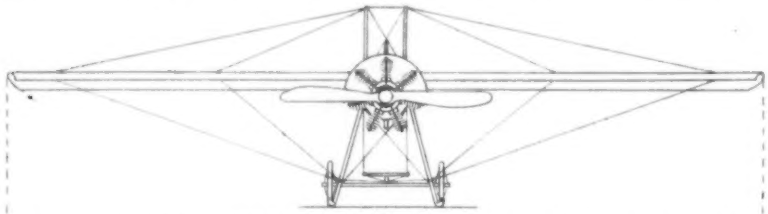
The construction of the wings follows conventional lines, with the exception that the trailing edge is laced to the ribs and is allowed a small degree of flexibility. The fabric is prevented from becoming saturated with oil by aluminium plates covering the under surface near the body. The wings are treated with "Emaillite," a preparation which renders the fabric weather and oil proof and keeps it taut. The covering of the body and tail planes are also treated with this varnish. In the racing model the wings are set perfectly flat, but in the other types they are at a slight dihedral angle to one another.

The passenger-carrying and school machines have purely flat triangular tail planes, but the racer has a tail of the lifting type. As there is every reason to believe that the non-lifting tail is the more efficient for a machine of this kind, the precise reason for the employment of a lifting tail is rather obscure. The elevator is hinged to the rear of the tail plane, while forward of the rudder extends a small vertical stabilizing fin.

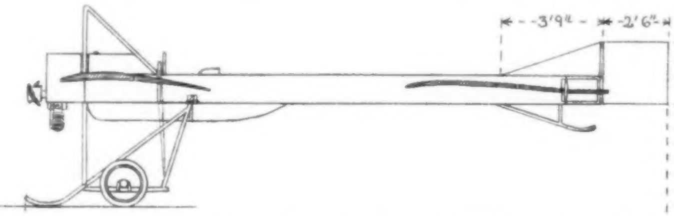
The control is one of the best points of the machine, giving, as far as space is concerned, the greatest possible amount of freedom to the pilot. Instead of using a vertical lever between the pilot's knees, as is the more usual arrangement, the Deperdussin has two side levers connected by a pinned crosspiece on which is mounted the handwheel. The rotation of the wheel corrects the lateral balance, while a to-and-fro movement controls the elevation. Steering is effected by the usual form of foot-lever.

The wires from the warping wheel are carried down to a T-lever mounted on the rear cross-member of the chassis and, after passing over pulleys on the skids, branch out into two wires each and proceed to two points on the spar of each wing. By rotating the wheel to the right, therefore, the whole of the rear spar of the left wing is pulled down, while the similar spar on the right wing rises a corresponding amount, and *vice versa*.

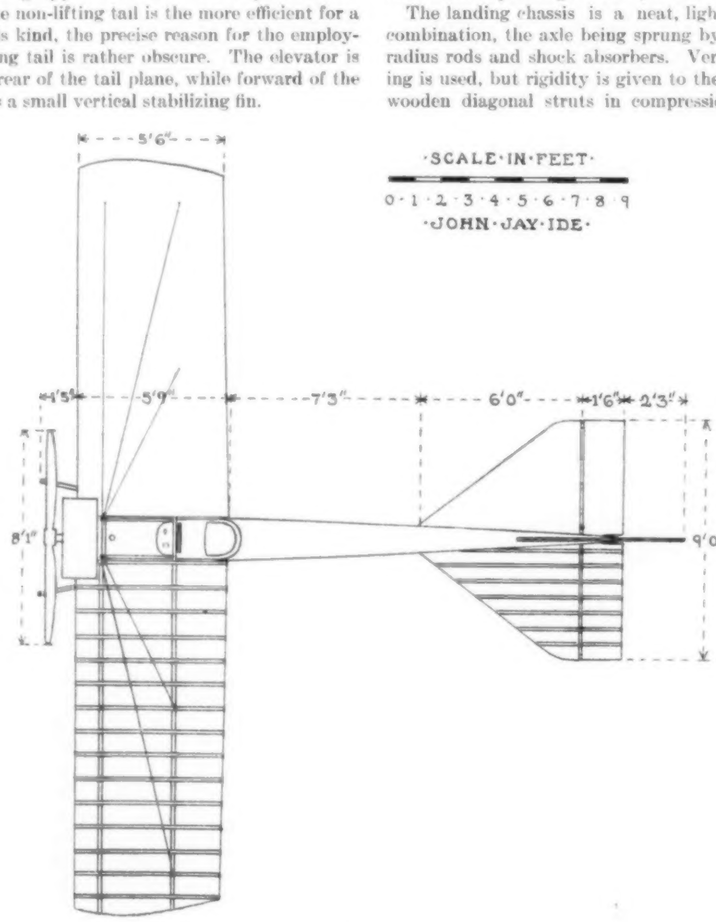
The landing chassis is a neat, light wheel and skid combination, the axle being sprung by the conventional radius rods and shock absorbers. Very little wire bracing is used, but rigidity is given to the structure by two wooden diagonal struts in compression. The forward



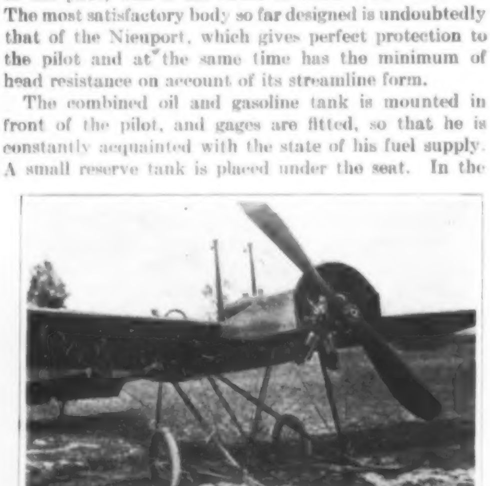
Front Elevation



Side Elevation



Plan



Front View of Type I. Monoplane.

The upcurved skids have been abolished in the latest military machine.

SCALE DRAWINGS AND PHOTOGRAPHS OF THE DEPERDUSSIN MONOPLANE.

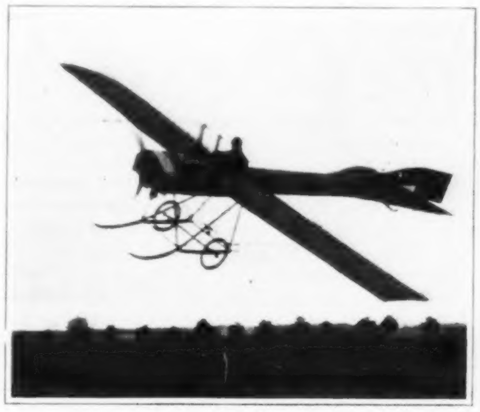
portion of each skid is an extension of each of these struts, and is connected to the skid proper by a thin band of steel to prevent the upturned front part of the skid letting the machine down too heavily in the event of a sudden landing. A rather peculiar point about the racing model is that the lower blade of the "Normale" tractor, when in the vertical position, comes below the level of the skids, so that in the event of a rough landing the screw is likely to get smashed.

The rear uprights from the skids are supported from the body in a neat manner. The clip which secures the vertical strut to the boat-shaped fuselage acts to a certain extent as a slide, the direct upward thrust caused by stress of landing being taken by a couple of stranded steel cables which encircle the curved keel of the body. The shock of landing is thus distributed over as large an area as possible and not centered in one point. A neat skid, hinged in the center and flexibly anchored at the top, protects the rear from ground contact.

The Deperdussin monoplane has achieved some very fine performances. The records on closed circuit which Busson made in the spring with three and four passengers still stand. With four on board the machine covered the fifty kilometers in 31 minutes, 23 seconds, just over a mile per minute. With five the time was naturally a little slower.

In the Paris-Rome race only one Deperdussin was entered. Under the guidance of young Vidart it was fourth at the finish in 171 hours, 13 minutes.

Five Deperdussins took part in the European circuit.



Deperdussin, Type L, in Flight.

The pilots were Vidart, Prevost, Pascal, d'Hespel, and Valentine. With the exception of Vidart none of them performed very well, although Valentine continued as far as London. Vidart, however, brilliantly sustained the maker's reputation by winning the first and last stages and being second in three others. In the general classification, he won third place with the time of 73 hours, 17 minutes, 16 seconds. Valentine was the only Deperdussin driver in the circuit of Britain. Although he had hard luck with his motor, broke his propeller, and experienced bad weather, he finally managed to complete the course and gain third place. Two machines, piloted by Vedrines and Prevost, were the only monoplanes besides Weymann's Nieuport to finish the strenuous tests in the recent military aeroplane competition, and to compete in the final race. By the above performances the Deperdussin has won a high reputation which it thoroughly deserves. Flying schools have been established in France, Belgium, and England. The machines are made and tested at Betheny, near Reims. To familiarize the pupils in the use of the controls, practice machines with 25 horse-power Anzani engines are provided. Quite a lucrative business is done in passenger carrying, two hundred francs being willingly paid for a ten minutes trip around the field.

Wire and Wire Rope on Aeroplanes

Useful Hints for the Flying Machine Constructor

By H. A. Whitney

THE solving of the problem of automatic balancing of aeroplanes, now receiving the serious attention of the ablest minds, will increase tremendously the safety and popularity of flying machines. So rapidly are improvements in the construction of aeroplanes being made that it is safe to predict that air travel eventually will be no more hazardous than travel by steamship, railroad or automobile. For the present, however, the aviator's safety and success depend, not only upon the possession of a well constructed aeroplane, but upon his skill, courage, persistence and knowledge of what his machine is capable of doing.

The remarkable yet fateful flight of Chavez over the Alps lends particular emphasis to this last statement. According to his own account, Chavez drove his monoplane through the baffling gusts of wind to a height of over 8,000 feet; then began the long free engine glide or series of volplanes. On the final steep swoop, the aeroplane attained terrific speed. At the moment when it became necessary to straighten up the machine, and, from pointing earthwards, bring it to an even keel, an extra strain was thrown upon the supporting wings and stay wires; the latter broke, the wings collapsed, and the machine and aviator were dashed to the ground. Chavez died from his injuries a few days later.

By similar breakdowns, due to the too sudden checking of rapid descents, several notable aviators lost their lives during the past year. Obviously, the designers and builders of aeroplanes are seeking the most dependable, light-weight engines, propellers of highest efficiency, the strongest and toughest wood, fabric metal fittings, wire stays, wire rudder cord, and aileron or wing warping cord.

IMPORTANCE OF STAYS AND FASTENINGS.

It must be apparent to persons at all familiar with aeroplane construction, that there is no more important part of an aircraft than the steel stays and fastenings that bind the otherwise fragile structure together, and give it the requisite rigidity and strength. As the trite saying that "a chain is no stronger than its weakest link" is particularly applicable to the assembled parts of an aeroplane, it is imperative that great care be exercised in selecting the quality and size of eye-bolts, turn-buckles, stay wires or stay strand that will afford as nearly as possible an equal and sufficient strength.

Let us first consider the merits of material available for stays. The American Steel and Wire Company were the first manufacturers to procure special wire, wire strand and wire cord to meet the exacting requirements of aeroplane constructors. With the most modern steel furnaces and the most skillful steel makers in the world, they are able to supply wire, wire strand, or wire rope possessing the best qualities for unusual conditions of use.

It is generally known that in no other form than wire can as great strength be obtained in the same area and weight. With this fact in mind, inexperienced builders of aeroplanes sometimes buy the strongest stay wire that can be produced, only to learn that such high carbon steel wire is necessarily hard and stiff and consequently difficult to fasten, lacks

* Abridged from *Electrician and Mechanic.*

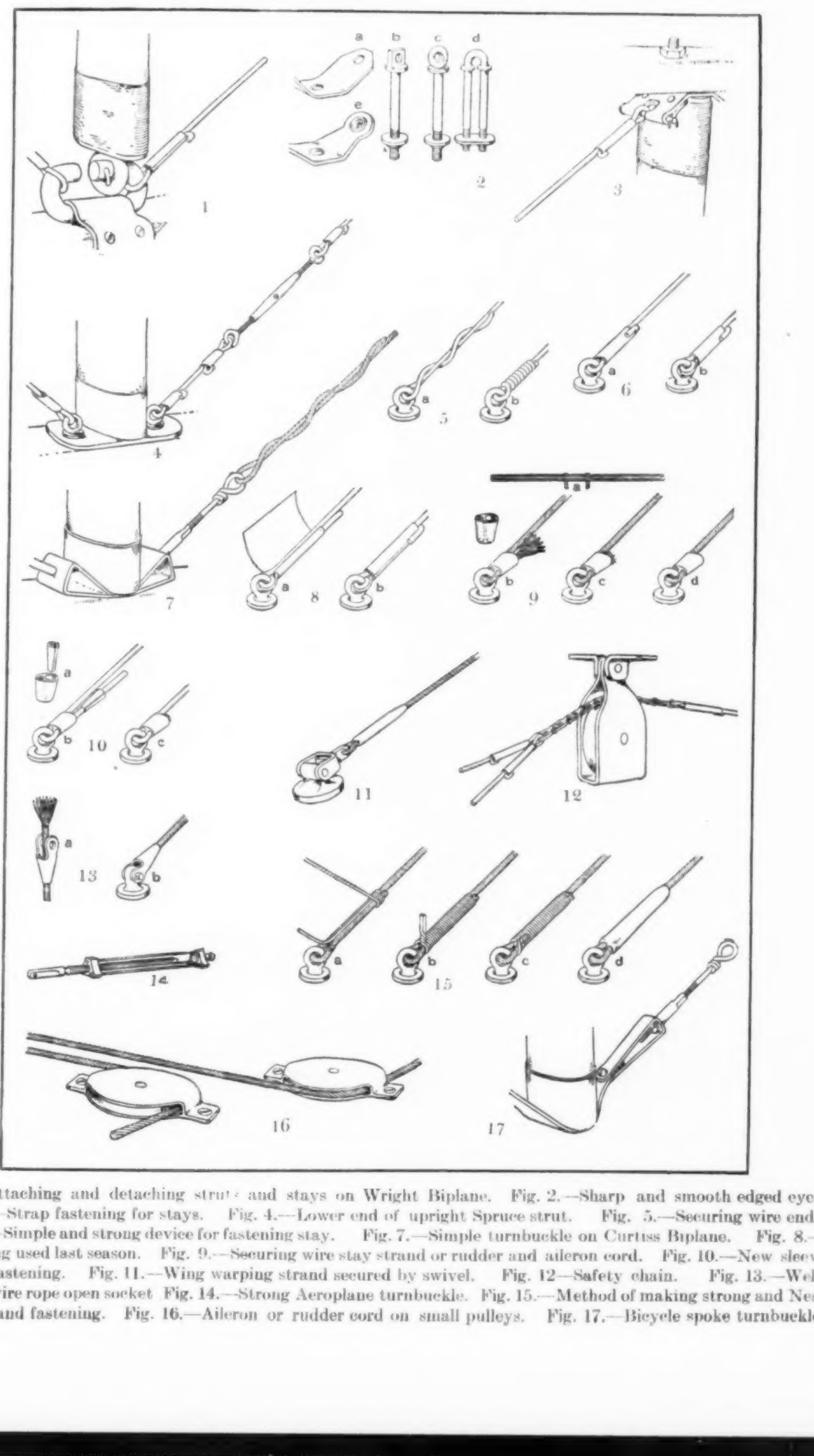


Fig. 1.—Attaching and detaching struts and stays on Wright Biplane. Fig. 2.—Sharp and smooth edged eyes. Fig. 3.—Strap fastening for stays. Fig. 4.—Lower end of upright Spruce strut. Fig. 5.—Securing wire ends. Fig. 6.—Simple and strong device for fastening stay. Fig. 7.—Simple turnbuckle on Curtiss Biplane. Fig. 8.—Fastening used last season. Fig. 9.—Securing wire stay strand or rudder and aileron cord. Fig. 10.—New sleeve socket fastening. Fig. 11.—Wing warping strand secured by swivel. Fig. 12—Safety chain. Fig. 13.—Well-known wire rope open socket Fig. 14.—Strong Aeroplane turnbuckle. Fig. 15.—Method of making strong and Nest Stay strand fastening. Fig. 16.—Aileron or rudder cord on small pulleys. Fig. 17.—Bicycle spoke turnbuckle.

toughness and will not withstand, without crystallizing, the vibration caused by the powerful engines.

DESIRABLE QUALITIES OF STAYS.

Experience has demonstrated that the desirable qualities of stays are good strength combined with toughness, to withstand bending and vibration; elasticity, to resist sudden strains; and protection against rust. Coating wire with tin or spelter—the latter accomplished by the process known as galvanizing—is the most common and effective way of preventing the deterioration of steel from atmospheric action. Tinned wire, although somewhat stronger than the same wire galvanized, does not resist corrosion nearly as long as the latter.

STAY WIRE.

There is on the market a special tinned or galvanized aeroplane stay wire that has all the strength that it is possible to secure without sacrificing toughness and elasticity. In the rigging of a well-stayed biplane, approximately 700 feet of wire is used. The sizes generally recommended are 0.070, 0.075, 0.080, and 0.085 inch diameter, and for the main stays that sustain the greatest strains, 0.090 and 0.095 inch diameter. If stay wires of ample size and strength are stretched taut when rigged on an aeroplane, turnbuckles are not absolutely necessary, although each stay is usually equipped with a turnbuckle or wire tightener.

STAY STRAND.

For reliable strength, light weight, flexibility, toughness and elasticity, the American galvanized high strength aeroplane strand, composed of nineteen galvanized wires, is unrivaled. The merits of this stay strand may be briefly summed up as follows:

The strength is distributed among nineteen small wires twisted into a concentric strand. The core of seven wires, comprising more than one-third of the total strength of the strand, is protected from injury by the outer layer of twelve wires. The efficient strength of a single steel stay wire may be tremendously reduced by a slight nick or abrasion of its surface, at which point it is then liable to snap under a sudden but not necessarily severe strain. The same accidental cutting or nicking of the stay strand probably would not affect more than two or three of the outside wires, the strength of the remaining wires being unimpaired.

A strand of small wires offers greater and more reliable strength than a solid wire of the same weight.

Being more flexible than a solid wire of the same strength the strand is more easily fastened to eyebolts.

Stay strand does not deteriorate from vibration as rapidly as a solid wire.

The wires are laid up spirally, giving the strand elasticity to withstand the sudden heavy strains to which the machine and stays are subjected.

The construction, weight and minimum breaking strength of American galvanized high strength aeroplane strand are here published:

Diameter.	Number of Wires.	Weight per 1,000 Feet.	Minimum Breaking Strength.
1/32 inch	7	2.3 pounds	125 pounds
1/16 inch	19	8.9 pounds	500 pounds
3/32 inch	19	17.0 pounds	1,100 pounds
1/8 inch	19	33.0 pounds	2,000 pounds

The strand is exact size and the breaking strength may be absolutely relied upon.

This stay strand is put up in coils of 50, 100, 500 and 1,000 feet each. For main stays, the 3/32-inch diameter strand is most commonly used, while the 1/16-inch and 1/32-inch diameter strand is employed in staying the elevating planes, the rudder frame, etc. It is best to place a turnbuckle on each stay strand in order to adjust and maintain a uniform tension, thus equalizing the stress on all parts of the machine.

FITTINGS AND FASTENINGS.

Although there is little available information on the subject, it ought to be generally understood that the method of fastening the wire or strand should be such as to equal the strength of the stay; yet the attaching of stay wire or stay strand to eye-bolts, eye-plates, and turnbuckles is sometimes accomplished in crude and inefficient ways.

For the benefit of aeroplane constructors, we show some of the present aeroplane stay fastenings and special fittings, together with illustrations of improved methods of securing wire, strand and cord, which by tests have been found very efficient.

Fig. 4 illustrates the lower end of an upright spruce strut, a strut socket and eye-bolts, and a common method of attaching a wire stay. This brass sleeve fastening and the bronze pipe turnbuckle are used on the Farman biplanes and Blériot monoplanes.

In Fig. 7 a peculiar yet light and simple turnbuckle is employed on the Curtiss biplane, this turnbuckle being nothing more than the rim end of a bicycle spoke inserted in a brass or steel strap, the spoke itself being cut off and twisted into an eye. In fact, this is known as a bicycle-spoke turnbuckle. On the latest improved bicycle-spoke turnbuckle, made by the Standard Company, the metal strip that goes under the strut is of steel. On the Curtiss machine, the strand is passed through the buckle eye, three or four long wraps are made about itself, and soft solder run into the grooves where the two parts touch. When it is desired to take up more stretch than the short length of the threaded portion of turnbuckle will allow, the long soldered wraps are readily untwisted, the turnbuckle lengthened, and the stay strand drawn taut and refastened. If the soldering is carefully done, this makes a satisfactory fastening.

Fig. 1 illustrates the convenient method of attaching or detaching the struts and aeroplane stay wires on the Wright biplane. This and other ingenious appliances are covered by patents owned and controlled by the Wright company. The stay wires are of good size and consequently have sufficient strength to withstand heavy stresses without appreciable elongation, thus making turnbuckles unnecessary. The loop in the end of each stay is secured by wrapping a strip of thin sheet metal around the two wires, the flat strip being soldered upon itself. The short end of the wire is then bent backward forming a hook over the metal sleeve. Note that the end of the spruce strut is bound with wire to prevent splitting. This wire seizing is stronger and lighter than a metal ferrule.

In Fig. 3, the strong brass or steel strap fastening for stays here shown makes it possible to remove the stay by cutting off the soft iron wire in the end of the steel pin and drawing the pin. This pin is simply a steel wire nail with a small hole drilled in the end.

In Fig. 2, wire or wire strand should not be bent around fittings having sharp edges that might cut or nick the wire and thus render it more liable to break under strain. For this reason, the thin brass or steel plate with a hole through it, *a*, and the steel eye-bolt with sharp edges, *b*, are objectionable. The bolts with smooth rounded eyes or loops, *c* and *d*, and the steel plate with a countersunk rivet or eyelet, *e*, will not injure wire nor strand.

In Fig. 5, the most natural and common method of securing the end of a wire, is here illustrated. There is a great difference, however, between the "holding" qualities of the long twist, *a*, and the close wind, *b*; the former slips and eventually draws out, while the latter, especially if soldered, is a very secure fastening for the small wire stays on elevating planes and rudder frames. There are better ways of attaching the larger main stays.

Fig. 6 shows one of the simplest, lightest and strongest devices for fastening a stay. The wire may be put through the eye once, *a*, but for greater security, a double wrap should be made in the eye-bolt, *b*. A steel tube is better than a brass sleeve, for the reason that the hooked end of a stay wire, when bent over the thin edge of the steel tube shows less tendency to straighten and pull out than when turned over the thicker and softer edge of the brass sleeve. These seamless steel ferrules, about 1 inch in length, have rounded edges to prevent cutting the wire. The round steel ferrule, when slightly flattened by pliers to an oval shape, should be just large enough to receive the two parts of the stay wire in order to obtain the best results.

Fig. 8 shows a strong fastening, quickly made, and was used on several well-known aeroplanes last season. The end of the wire, after passing once or twice through the eye-bolt, is bound back upon the main wire by wrapping the two parts with a thin metal strip about 2 inches in width. The wire is bound tightly by the metal strip which is then soldered upon itself and the projecting end of the wire bent into a hook as shown.

Fig. 10 shows a new sleeve socket fastening, *a*, for stay wire that is quickly and securely applied by passing the wire through the socket and eye-bolt as shown, *b*. The split cone sleeve is then slipped over the end of the wire, and with a short length of steel tubing and a hammer, the sleeve is driven into the socket bowl, the end of the wire cut off, and swaged over the head of the split sleeve by a few light taps of the hammer, *c*. The ends of the holes in the socket are rounded or beveled to prevent cutting the wire. This sleeve socket fastening should equal the strength of any stay wire.

Fig. 9, for securing stay strand or rudder and aileron cord, the socket shown in Fig. 10, *a*, may be used, but without the split cone sleeve. Before cutting wire strand it is well to bind it temporarily with soft wire either side of the point where it is to be cut, in order to prevent the strand wires untwisting, *a*. After dipping the ends of the strand or cord in molten tin or solder the binding wire may be removed. The soldered end of the wire strand is then readily inserted in the socket. Two or three wraps of very fine tough wires are made about the strand or cord 1 inch from the end and the wires untwisted, as shown at *b*. By pinching the soldered end of the strand with pliers, the wires are easily separated and untwisted. The loose ends of the wires are then cleaned with benzine and coated with soldering paste, which is best applied with a brush. The soldering paste known as "Nokorode," is very satisfactory for this purpose. The end of the strand is then drawn back into the bowl of the socket as at *c* and molten spelter is poured into the socket about the wires. Any projecting ends of wires are cut off and the fastening is complete, *d*.

In Fig. 13 the well-known wire rope open socket of a small light pattern is here shown fastened to a stay strand. To attach this socket, the soldered end of the stay strand is passed through the socket, two or three wraps of fine tough wire are made about the strand as illustrated at *a*. The wires are then untwisted, cleaned with benzine and doped with "Nokorode" soldering paste. The strand is drawn back into the bowl of the socket until the ends of the wires are flush with the large end of the socket bowl. Molten spelter is then poured into the socket and, adhering to the wires, forms a solid mass of spelter and wire which cannot be pulled through the socket, *b*. By the use of open sockets, stays may be fitted complete of the proper length and readily attached or detached as occasion requires.

The illustrations in Fig. 15 explain the method of making a very strong and neat stay strand fastening. The soldered end of the strand after passing through the eye is temporarily tied to the main part with string or wire if necessary. Tough annealed iron wire or soft brass wire used for seizing, is first laid into the groove between the two parts of strand. About 3 inches from the eye, the seizing wire is given a right angle bend and the wrapping begun, *a*; the ends of the seizing wire are twisted together, *b*, and laid against the seizing, *c*. The wires in the short projecting end of strand are next loosened or opened by pinching with pliers, *c*. This is done in order that the solder may adhere to the wires and form a knob that cannot pull out of the seizing. The entire seized fastening is then cleaned with benzine, coated with soldering paste, and heavily soldered, *d*.

If the surface of tinned or galvanized stay wire or stay strand has been scratched in securing it to eyebolts, rust spots will soon appear, especially as the moisture settling on the stay runs down and collects on the fastening itself. It is, therefore, a wise precaution to paint all stay fastenings with black asphaltum paint or turpentine japan.

Fig. 11. On Santos Dumont's diminutive monoplane, the wing-warping strand is secured to the wings by the swivel fastening here illustrated. There is no movement of the strand at the loop, which would tend to abrade the fine wires of the strand, because the swivel allows the strand to pull directly from the eye regardless of the angle of the wing.

The Wright biplane is equipped with American tinned aeroplane wire, not only for stays, but for the wing-warping and the rudder lines. Where a turn is made over a sheave with a wing-warping or rudder line, a short length of flat link or safety chain is inserted at the pulley as shown in Fig. 12.

In Fig. 14 the strongest aeroplane turnbuckle for its weight yet devised for use with wire, is here illustrated. The heads are of chrome steel connected by three high carbon steel piano wires. The threaded screw is also of piano wire. A turnbuckle of this pattern, size No. 7, having a take-up of 2½ inches, weighs one-half ounce and will sustain a stress of more than 600 pounds. Owing to its peculiar construction, it is quite expensive.

Fig. 17. The bicycle spoke turnbuckle, fitted with a steel strap (not brass) that may be bolted to the steel strut plate, is probably the most generally approved combination stay fastening and tightener. The common turnbuckle inserted between the terminals of the stay, requires four separate fastenings of the wire or strand in each stay, whereas by the use of the bicycle spoke turnbuckle, placed at the lower end of a stay, only two fastenings are necessary—a considerable saving in labor and expense in the rigging of a biplane with more than 100 stays. The tendency of turnbuckles to loosen from constant vibration may be prevented by wrapping with electrician's rubber-lined friction tape.

Probably at no distant date, aeroplane supply catalogues will give not only the weight, but the guaranteed strength of all aeroplane appliances. Until this is done, the prudent constructor will adopt American galvanized high strength aeroplane strand and cord, and then by actual test, select turnbuckles and fastenings of equal strength.

CONTROL ROPE OR CORD.

As is generally known, the lateral balancing of aeroplanes is accomplished either by warping the wings or by varying the angle of incidence of the ailerons, small hinged flaps on the outer rear edges of the main wings. The wing tips and the ailerons are connected

by a small wire rope or wire cord, leading through suitable pulleys, to the operating levers or wheel, or to the shoulder fork that embraces the aviator's body. The wing-warping cords on the Santos Dumont monoplane are connected to a tube sewed into the back of the operator's coat, so that by the swaying of the aviator's body, the wings are bent and equilibrium maintained. From the control levers or wheel, wire cords also connect with the rudder, elevating planes, brake, and engine throttle. For all of these important control lines, the American Steel & Wire Company have designed and now offer a special wire cord known as American galvanized flexible steel aileron or rudder cord, the 3/32-inch diameter composed of twelve strands, of three wires each; the ⅛-inch diameter having nineteen strands of three wires each. This cord combines great flexibility and strength with the minimum amount of stretch, and the strength being divided among many wires, it is a much safer control line than a single wire. The cord works freely over small pulleys in any direction (see Fig. 16), and avoids the necessity of introducing chains at the pulleys where a single wire is employed. Common galvanized sash cord of six strands of seven wires each, and a cotton center, should never be used for control lines, because it lacks strength and stretches too much. American galvanized flexible steel aileron or rudder cord, which has met with the immediate approval of the ablest aeroplane constructors, and aviators, is made in two sizes:

Diameter.	Weight per 1,000 Feet.	Breaking Strength.
3/32 inch	15.5 pounds	725 pounds
1/8 inch	24.5 pounds	1,150 pounds

In order to obtain the best wire or strand for stays and the most reliable cord for control lines, the buyer should order direct from these sales offices or supply houses known to handle these goods.

The Prevention of Dental Caries*

The Influence of the Character of Food on the Health of our Teeth

By J. S. Wallace, D.Sc., M.D., L.D.S.

THE decay of teeth, technically "dental caries," is one of the most easily and certainly preventable of diseases, and there would seem now to be no valid excuse for the bringing up of children with decayed teeth, together with all the pathological results which they give rise to. Unfortunately, so far it is only those who have become interested in the subject and who are themselves possessed of the required knowledge to come to correct conclusions on the subject, who know the simple secrets of prevention, that is to say, a goodly proportion of the dental profession, and here and there a few medical men who have paid attention to the long and laborious investigations which have led to the solution of this important problem. It is with the idea of letting what is already known to a few become more widely known, among medical men more especially, that I venture to publish this pamphlet. Those who find the subject of interest or importance would do well to make their knowledge more secure, by acquainting themselves not only with the outlines of the means of preventing the disease as presented in these pages, but also with at least a general knowledge of the pathology and the etiology of the disease, because for some considerable time, incredulity, ignorance, prejudice, vested interests and the commercial spirit are likely to continue to make a stubborn resistance to the diffusion of the truth. It would be a great service to mankind if a goodly number of medical men would become thoroughly acquainted with the subject so as to rid the land of ideas which are now definitely known to be wrong, and indeed often actually markedly instrumental in causing the disease. Medical men should certainly make sure that it is not their precepts which are largely responsible for the widespread prevalence of the disease. Those who would like to supplement their knowledge may be recommended to consult the more recent standard text-books, e. g., J. F. Colyer's "Dental Surgery and Pathology," or the larger "System of Dental Surgery," edited by Mr. Norman Bennett, about to be published by the Oxford *Medical Press*. Therein they will find the ground work of the subject sufficiently and thoroughly treated to let them master all important points. The references at the end of this pamphlet will also help anyone with regard to any special point on which he may desire to have further information.

ON THE MEANS OF DISSEMINATING KNOWLEDGE NECESSARY FOR THE PREVENTION OF DENTAL CARIES.

From what has already been said it is obvious that the cleansing power of true or effectual mastication is better almost beyond comparison than artificial cleaning. Efficient mastication not only keeps the teeth clean and free from injurious plaques of bacteria, but the gums are kept clean, healthy, firm and so finely applied to the necks of the teeth as almost to defy the lodgment of all appropriate kinds of foods. The peridental membrane and alveolar processes are kept strong and healthy, and no doubt the gingival organ is likewise benefited. The bones of the jaws also are stimulated in their development, and the teeth are more perfectly implanted and regular than when mastication has been insufficient, and artificial cleansing has been solely relied upon for their welfare. Moreover, digestion and the general health are both directly and indirectly benefited. It is, therefore, the obvious duty of every dental practitioner to instil into his patients the value of efficient mastication, and to get them to understand that no amount of artificial cleansing will make up for the continual transgression of the dictates of physiology, and that this is doubly important with regard to growing children whose habits have yet to be formed. It is hardly necessary to say that the attempt to teach the art of vigorous mastication is *perfectly futile* unless the food is of such a consistency as will stimulate or require it. From Dr. Black's Phago-dynamometric records we observe that the vigor of mastication *is and must* be proportional to the consistency of the food consumed, if the food is masticated at all. Here, however, we are met with a difficulty, for if medical practitioners advocate soft food for children, as in actual practice they very generally do, and the dentist advocates its discontinuance, then the diffusion of the required knowledge is greatly impeded. As the general medical practitioner comes in contact with children at a much earlier age than the dentist does, great havoc may be wrought in children's mouths and teeth before the advice of a dentist may even be thought of. It is, therefore, obvious that medical men must learn or be taught how the mouth may be most effectually kept clean. There are few indeed who realize that the mouth is, or at least ought to be, much cleaner after a meal which really requires mastication than at any other time. The detergent effects of the foodstuffs have admittedly been overlooked. It is not so very long since the idea that a meal invariably left the mouth dirty was generally believed even by dentists, so that we can hardly expect the public to be converted at once to the idea that the meals themselves should be cleansing to the mouth and teeth. It is not too much to say that, notwithstanding its immense importance from the point of view of general health, the natural hygiene of the mouth has in the past to all intents and purposes been entirely overlooked. It is true that artificial cleansing of the mouth has been insisted on, but that some foods leave the mouth physiologically clean, while other leave it dirty, seems never in any text-book of dietetics to have been so much as mentioned. Foods which lodge about the teeth and do not clean the mouth, have been recommended without the slightest concern as to whether they kept the mouth, and indirectly the alimentary canal, free from chronic fermentation, so long as they were known to be easily digestible and to supply the requisite amount of proteid, carbohydrate, etc. In fact, the viewing of food from its nutritional and not its hygienic value is still a matter for serious regret among those who understand the value of oral and indirectly alimentary hygiene. Thus in reviewing an important medical book recently published, the *British Dental Journal* said, "We are at the outset pained to find that wherever a dietary is given in detail in this work, as being specially adapted for school children, no thought apparently has been given to the fact that human teeth are primarily intended for mastication and that upon the functional activity of the teeth depends the proper development of the jaws; again, we would point out that a diet should be so arranged as to provide a natural toothbrush, and not be composed of those very ingredients which on fermentation lead to the production of lactic acid and consequent decalcification of the dental enamel." It is obvious that the first thing required for the diffusion of the requisite knowledge is to have it clearly taught in text-books for dentists and medical practitioners. We may say that as far as dental text-books are concerned this has just recently been done. With regard to medical text-books, unfortunately the importance of the subject has not yet been fully realized by all the writers. Some, however, have recognized the more modern teaching of dentists, and further have advocated an abandonment of the current practice of pap feeding for children, not only on account of the teeth, but because of harmfulness with regard to the alimentary canal and body generally. Notwithstanding this, however, it would seem desirable that more attention should be paid to the hygiene of the mouth by medical practitioners, and only good would result from requiring from medical students an elementary knowledge of the principles of oral hygiene. Moreover, fuller recognition of dentistry as a branch of medicine at the universities where medical degrees are granted should be demanded. All this is important because the subject of oral hygiene is necessarily associated with questions of dietetics, and consequently in this matter it is to the medical profession that the public look largely for guidance. As regards the dental branch of the profession, it has been and is doing excellent work so far as that is possible under existing circumstances. The British Dental Association and the School Dentists Society, have made statistical investigations which have done much to awaken both the medical profession and the public to the great importance of the subject. Here it is hardly necessary to say that the treatment of school children's teeth should always be accompanied by instructions as to the prevention of the disease. Otherwise the chronic irritation of increasing taxes, and the almost certain recurrence of the disease within a few years will most assuredly give rise to the suggestion that such treatment is not initiated by the highest motives. This would be a great misfortune, because the treatment of school children's teeth is itself of importance in preventing further caries. It makes the children able to eat food suitable for the hygiene of the mouth and alimentary canal, together with all its concomitant and consequent advantages. From what we have just said it may be observed that the best means of educating the public is through what may be called the recognized channels; that is to say, those with special knowledge must expound the subject in such a way that the leaders of medical thought and writers of text-books shall become acquainted with the truths, and when this is done there is but little fear but that the truths will gradually become generally known. The public have always looked to the medical profession for guidance, and there is no higher authority to whom they are able to appeal, and therefore no efforts should be relaxed, either in regard to perfecting the knowledge of the medical practitioner in this special branch of learning, or in bringing before his notice the reasons for considering the hygiene of the mouth as the most important part of preventive medicine.

There is appended a table of foodstuffs classified in their relation to dental caries.

NOT CLEANSING AND LIABLE TO INDUCE CARIES.

Farinaceous and sugary food in general without fibrous element.

Examples: Sweet biscuits and cake; bread and marmalade; bread and jam; new bread without crust; bread soaked in milk; milk puddings; porridge and milk; stewed fruit; chocolate and sweets of all kinds; honey.

Liquids: Cocoa and chocolate.

The above foods should not be eaten except when followed by foods of the cleansing kind.

CLEANSING AND PREVENTIVE OF DENTAL CARIES.

Fibrous foods generally.

Examples: Fish, meat, bacon, poultry. Uncooked vegetables, lettuce, cress, radish, celery. Cooked vegetables are as a rule cleansing, but in a less degree than uncooked vegetables.

Stale bread with crust; toasted bread of all kinds; twice baked bread; pulled bread and cheese. Savories. Fresh fruits, especially those requiring mastication, e. g., apples. Fatty foods, e. g., butter and margerine. Liquids: Tea, coffee, water, also soups and beef tea.

* Resumé in the *Dominion Dental Journal* of a pamphlet published by *The Dental Record*.

Public Revenue from Roadside Fruit Trees

THE sales of native fruit grown on the trees bordering the country roads in the township of Linden, near Hanover, yielded this autumn $4,906. Along certain stretches of these roads the yield has amounted to $595 per mile. The Province of Hanover has some 7,000 miles of country highways bordered with fruit trees, the profit of which is appropriated toward the upkeep of the roads.—*Consul Robert J. Thompson in Daily Consular and Trade Reports.*

Modern Steam Boiler Automatic Water Regulation

An Important Feature in Modern Power Practice

Automatic regulation of the water supply to steam boilers is now extensively employed and modern devices have entirely overcome the prejudices of steam users against automatic boiler feeding.

The accompanying illustration Fig. 1 shows feed water regulators attached to boilers in a power house at Philadelphia, while the line-drawings Figs. 2 and 3 show the arrangement of similar regulators on one of twenty-six 250-horse-power vertical boilers at the power house of the Duquesne Steel Works of the Carnegie Steel Company at Duquesne, Pa.

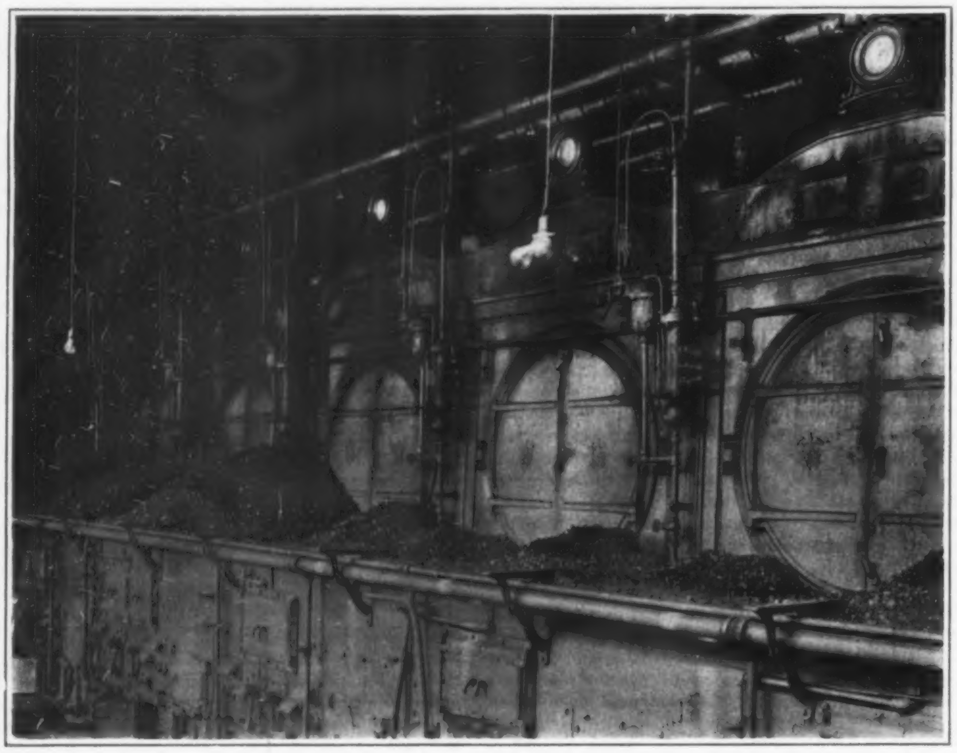


Fig. 1.—Feed water regulators in a Philadelphia Boiler House.

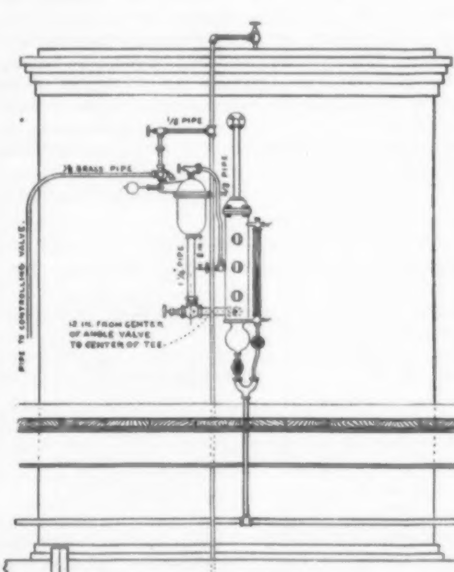


Fig. 2.—Feed regulator on a 250 horse-power vertical boiler of the Carnegie Steel Co.

The importance of keeping the water level in steam boilers constantly at the proper point has always been recognized, and with the modern water tube boiler, containing but a small amount of water per square foot of heating surface, and its enormous and rapid steam production, the regulation of the water supply has become much more difficult and requires constant attention.

The modern automatic system of boiler feeding is designed to meet this difficulty by the provision of a feed water regulator on each boiler and a pump governor on the feed pump. By this means the water level is kept at a fixed point, usually the middle gage, irrespective of the load or firing of the boiler, and water is admitted a little at a time in exact proportion to the amount of steam produced. The apparatus may be applied to one or any number of boilers in a battery or to any type of boiler. It is stated that no hand regulation, however competent, can approach the uniformity with which this system will hold the water levels to a given point, and no attendant can give the boilers the same careful and untiring attention as the mechanical feed device.

The desirability of carrying the water at a fixed line in the boiler has long been recognized and with the large factor of safety with which all boilers are now designed and the careful yearly inspection, to which most of them are submitted, it may safely be said that the most frequent, if not the only cause of boiler explosions is low water.

The regulator is based on gravity-feed, so that it cannot fail to operate and keep the boiler supplied with water as long as there is any water to feed. The controlling valve is constructed in such a manner that the feed water will lift it and fill the boiler in case anything should happen to the regulator itself, so that the danger of explosion owing to low water is practically eliminated.

Few owners of steam boilers realize that each boiler holds the same explosive force as a magazine of gunpowder, and that each day they stake their lives on the care of one of their lowest-paid employees.

Boilers are designed to work most economically when the water is at the middle gage, for at this point there is the maximum heating surface and the maximum steam space. There is a tendency to fill a boiler too full, so as to be on the safe side. If a boiler is filled to three gages, not only is the temperature of the boiler lowered, but the extra gage of water is above the point of contact with the heat, and a large percentage of the heat in the fuel, which must be burnt to convert the water into steam, is wasted.

Without question, the more regularly a boiler works, the greater is the economy. The best possible condition is reached when the water level is kept uniform, for then the heat is constantly applied to the same amount of water at the same temperature. The slow and uniform feeding of the boilers by the regulators causes a further saving of fuel in the feed water heater or economizer, because the regular speed of the water through the latter allows the feed water to be always heated to a higher degree than is possible when the flow varies, as is always the case with hand feeding.

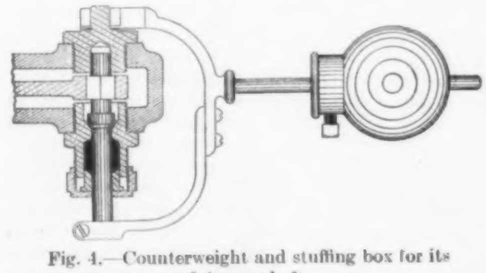


Fig. 4.—Counterweight and stuffing box for its fulcrum shaft.

The saving in fuel effected by the use of these machines over hand regulation is said to be from 6 to 15 per cent. A properly designed boiler will not prime or permit its water to be carried over into the steam pipes if the water level is kept at the middle gage, and most cases of boiler priming and water in the engine cylinders are due to carelessness of the attendant in allowing the boiler to get too full of water, the remainder being due to bad water or undue forcing. This causes a great loss in cylinder lubrication to say nothing of scored cylinders and accidents from water in the cylinders.

It is claimed that the regulator system here described will hold the water level at the middle gage even in boilers forced far beyond their rated capacity and will insure dry steam at all times. The use of automatic feed water regulators also increases the durability of the boilers and reduces the repairs materially, as the boilers are spared the strains of expansion and contraction which are inseparable from hand feeding.

As the regulators admit the water a little at a time the boilers are not chilled by changing water levels and temperature, caused by feeding in considerable quantities of water, even from a heater at 200 degrees, into the boiler at 350 degrees. This expansion and contraction is responsible for the many leaks around tubes, and the use of a regulator will greatly diminish the yearly boiler repairs.

For use on boilers fired with either blast furnace gas or waste heat from heating and puddling furnaces these machines are invaluable owing to the great fluctuations in the heat applied (due to the varying operations in the furnaces), the variation in the production of steam is so great that the most careful hand regulation cannot keep the water level uniform.

The feed water regulator includes a special combination union angle nipple screwed into the water column at the middle gage cock opening, and from the union of this valve a three-eighth-inch pipe connection is made to the top of the chamber of the regulator. To this a hooded chamber is attached, being placed as close to the column as possible, with its bottom not less than eight inches above the point at which it is desired to carry the water level. A 1¼-inch connection is made from the bottom of the chamber to the boiler or to the bottom connection of the water column.

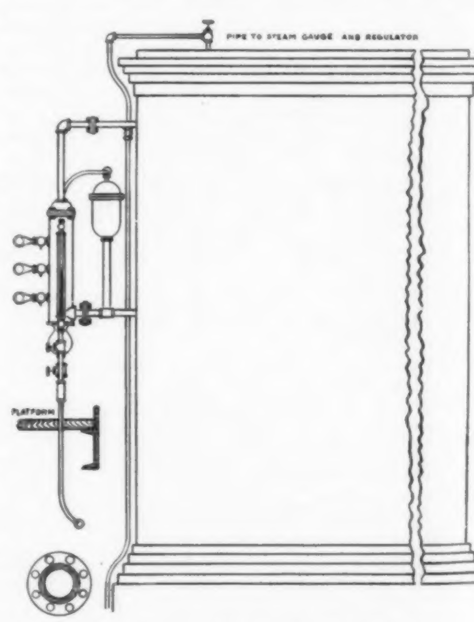


Fig. 3.—Side view of the boiler shown in fig. 2.

On the top of the hood is a small pet cock for blowing out any accumulation of air, a combined pet cock and union being used for this purpose. Inside the chamber is suspended a weight or displacement body

which is hung from the end of the lever, whose fulcrum is a shaft, one end of which extends through a stuffing box, while the other rests on a step inside. The stuffing box is not a necessity, for the shaft that passes through the stuffing box is provided with a ground point on the interior of the stuffing box, which would hold the steam if the packing in the stuffing box were removed, as indicated in sketch Fig. 4. To the protruding end of this shaft is keyed another lever which carries an adjustable counter-weight and at the fulcrum has a shoe with an adjustable set screw for lifting the stem of the actuating valve. This valve is attached to the top of the hood, and a steam connection is made to the gage pipe or other pipe where dry steam may be obtained. The valve has an upper and lower seat so arranged that when the valve is against the upper seat, the steam connection is shut, and the bottom one is open to the atmosphere. When the valve is seated on the bottom seat the connection to the air is shut and the steam pressure is admitted to the controlling valve. This latter is placed in the feed line to the boiler and in construction is similar to a check valve, the entering water tending to lift the valve. There is a stem which extends from the valve to a chamber located in the cast iron loop, and which is connected to a piston moving in the chamber. The upper cover of the chamber forms a reservoir for water which prevents the live steam reaching the piston cups. Under the piston is a spring which assists in opening the valve when there is no pressure on the piston. As soon as the water level in the column is below the opening of the special nipple, steam enters the chamber of the regulator and the water in it is displaced, falling through the pipe at its bottom to the level of the water in the water column. The weight or displacement body in the chamber then falls by gravity to the bottom of the chamber, the counterweight and lever rise, holding the actuating valve against its top seat, and the exhaust valve opens to the air. There is then no pressure on the piston of the controlling valve, and the latter is wide open and the boiler takes in water.

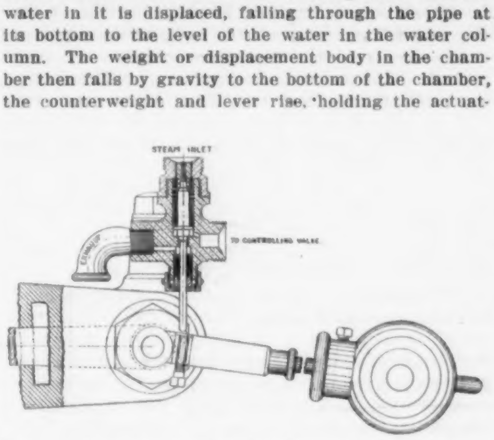


Fig. 5.—Side elevation of the features seen in fig. 4, showing also the actuating valve and its stem controlled by the lever arm.

As soon as the boiler fills up to the opening of the special nipple, this will be sealed by the rising water, and steam will be cut off from entering the chamber, while that which was in the chamber will be condensed, forming a partial vacuum, so that the water from the boiler instantly fills the chamber up to the top. The apparent weight of the displacement body is now reduced by the weight of water which it displaces, and the counter-weight or outside weight is heavy enough to overbalance the inside weight and goes down, while the inside weight goes up. As the outside lever goes down, the actuating valve goes down also, opening the steam connection and shutting the exhaust.

The steam pressure is admitted to the piston chamber of the controlling valve, noted in drawing Fig. 5, and forces the piston and valve down, and shuts off the feed water at once. No more water can enter the boiler until the water level falls to the opening of the special nipple, when steam is admitted to the top of the chamber, the water in it falls to the old level, all the operations are reversed and the controlling valve opens again. These operations are repeated as the water gets above or below the desired point and the vibration and variation does not exceed one-half inch. When the counter-weight is up, it is known that the boiler is feeding, and when down, that it is not.

In case the boilers are fed by injectors, the controlling valve is placed in the steam line of these, the operation being the same as described above, except that the controlling valve now regulates the current of steam to the injector instead of the feed water as before, but by this means obtaining the same results. The injectors must be of restarting type.

Power Derivable from Ocean Waves*

A Scientific Analysis of the Case

By Franklin Van Winkle

Dynamic theories of water waves have been the subject of inquiry by many eminent engineers and scientists. The results of their researches tend to show that the energy created by ocean waves, whether derived from the action of tides, winds or other forces in nature, is eventually expended in lifting, tossing and driving the water in innumerable forms of motion. During periods of extraordinary disturbances, the water's surface and subsurface energies are extremely complex. In many places these disturbances are augmented by combinations of local conditions and neither the surface nor subsurface waters hold to a uniform degree of activity for any considerable length of time. These features are true of localities where during times of ordinary ocean storms the impulses of waves have been known to exceed 3,000 pounds to the square foot; but such places would be entirely unsuitable for the location of wave motors, because of the great difficulty in securing stability of mechanism and regularity of the propelling power.

Modern methods have made possible the storage and long-distance transmission of power developed from irregular sources; hence the problem of obtaining power from ocean waves is an encouraging one. But in view of the inconstancy of the energy, the doubtful efficiency and hazard attending the construction of plants designed for utilizing energies of the deep sea, it is fair to ask that practicability of wave motors should first be demonstrated in shallower waters, where all elements are under greater control. Although subsurface activities are usually concomitant with surface activities, one may exist without pronounced development of the other. Water in an ordinary tank may have its surface disturbed into the formation of waves without creating a perceptible subsurface disturbance beyond the body of the surface wave form itself; or, on the other hand, the whole body of water in the tank may be agitated and may be brought to rest again, without a perceptible formation of surface

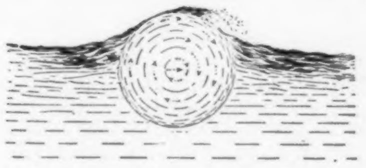


Fig. 1.—Apparent Rolling Effect.

waves. In the latter case the particles act and counteract on each other and on the sides of the containing vessels, assuming swirls and eddies or setting up a churning action which is accompanied by surface froth and foam.

When subsurface energies resolve themselves into surface forms, it is the result of unbalanced kinetic energies recovering their equilibrium by overcoming the force of gravity in lifting some of the water and thus storing potential energy in the wave form above the general level. When conditions are favorable to this manner of forming the surface wave, its propagation continues in the same manner until complete equilibrium is established by one-half of the original subsurface kinetic energy being converted into potential energy. But when conditions are not thus favorable for the transformation of one-half of the kinetic into potential energy, the subsurface forces, in seeking equilibrium without having parted with any of their original intensities, when opposed, as by coming in contact with stationary objects, naturally assert themselves with double the violence. Hence, havoc is frequently wrought by the pounding and boring action of the sea at times when surface waves are insignificant. Many people have the mistaken idea that surface and subsurface energies are in direct proportion to the height of the surface form of the latter.

Before passing to a consideration of the energy of the ordinary forms of waves a few further observations may not be amiss respecting subsurface energy. Until subsurface disturbances have worked themselves into some uniformity of wave form, the kinetic forces are exceedingly complex and confused. When the kinetic energy is in the form of a steady stream, as in the instance of a tidal current flowing through a narrow channel, then the energy of practically the whole body of water continues as kinetic energy, and the problem of obtaining power becomes identical with conditions that are met by the installation of current waterwheels. This is not only one of the oldest methods of obtaining power from water, but also one of the most expensive, in proportion to the amount of power obtained.

In view of the energy with which waves are hurled against cliffs and masses of masonry, it might seem probable that an area placed normal to the general wave action would present favorable opportunities for the development of power. The fact remains, however, that when kinetic activities of the water are thus expended they are extremely irregular. In localities where wave action of this kind is continuous, the task of installing a plant for intercepting the energy of the water would be very hazardous and of doubtful permanency. But assuming that the difficulties of construction and maintenance are overcome, the kinetic action has to be received and absorbed in the form of irregular impulses varying from violent impacts to negative hydrostatic pressures due to the "suction-like" action of receding volumes of water.

The simplest forms of ocean waves are those which are propagated in deep water and they are referred to in this connection mainly because the fundamental theories of the simple wave motions are based upon deep-water conditions. It may be said in passing, however, that the leading characteristics of shallow-water waves, which are most likely to be considered for imparting energy to wave motors, are analogous to those of deep-sea waves.

Extensive and critical observations of ocean waves made by officers of the French and English navies and by independent experimenters on wave motions produced in large glass tanks, appear to confirm the leading principles of wave motions that are deducible from what is termed "the trochoidal-wave theory." This theory is based upon the motions which are set up in deep-sea waves ordinarily known as "rollers" when such waves are propagated uniformly and in a regular and uniform series. When a simple deep-water wave passes over a point, each surface particle and the particles of all the water to a considerable depth describe circular or elliptical orbits in vertical planes which are perpendicular to the ridge of the wave. Under normal conditions it is assumed that the particles describe orbits which are true circles; that they travel in their circular orbits at uniform rates of speed once during the passage of a complete wave form measured

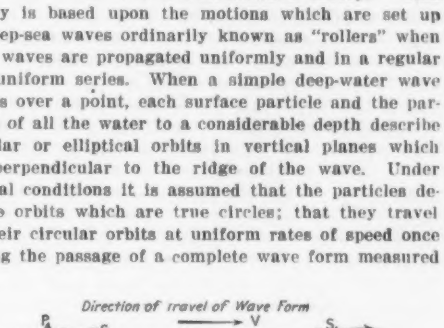


Fig. 2.—Successive Positions of Float.

from the center of a crest to the center of a succeeding crest; and that the profile of the wave surface takes the form of a trochoid.

The term "roller," commonly used with reference to wave motions, is undoubtedly derived from a popular but erroneous notion that wave motions consist of

* Reprinted from *Power*.

progressive rolling over and over of a body of water in the form of a cylinder or roller partly submerged below the general surface, as indicated in Fig. 1. There is some excuse for this opinion; for the crest of the wave and its rounded form of breast and back down to about half of the total depth of the wave, partake of motion in the direction of travel of the wave form, resembling the upper part of a rolling cylinder.

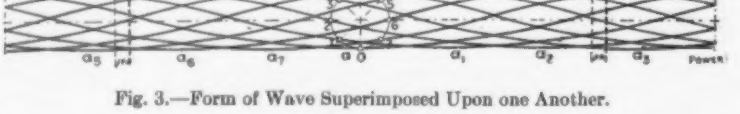


Fig. 3.—Form of Wave Superimposed Upon one Another.

From a geometrical analysis of the motions of the particles it will be seen that in the ordinary, fully developed deep-water wave, the "rolling-cylinder" idea is not confirmed but that the particles move in orbits whose centers are fixed, except for a lateral motion which they may assume along with shifting of the whole body of the water, which is very small in comparison with the speed at which the form of the wave travels over the surface of the water.

Special attention is called to the fallacy of the "rolling-cylinder" idea to guard the reader against receiving any such impression from hasty perusal of the diagrams of wave motions. The orbits of individual particles, drawn as complete circles or ellipses, are often wrongly construed as illustrating solid cylindrical bodies of water.

ACTUAL MOTION OF PARTICLES.

Assuming that the actual motions of a small group of surface particles of the wave are the same as that of a small float carried on the wave, a study can then be made of the motions of the surface particles from observations of the motions of the float. By photographing the float, from a stationary position, allowing the exposure sufficient time to get the complete passage of a wave, if the float affords good reflection of light in strong contrast with light received from the surface of the water, a view may be had of the path of the float in a single exposure. If there were no general forward motion of the whole body of water, an exposure continued during the period of two or more wave lengths would show the path in the form of a continuous curve, repeating once for each wave length. But the form of curve and the velocity with which the float passes over different parts of its path could be best ascertained by taking a series of instantaneous photographs at equal intervals of time. Such a series of photographs of consecutive positions of the float, and corresponding positions of the wave, would resemble the series shown in Fig. 2, in which a small float is represented in the successive positions at P, P_1, P_2, P_3, etc., finally assuming the position P_8 identical with the original shown at P. One would expect that if the wave crest had a uniform advance in the direction of the arrow V, the form of wave in each case would be the same, excepting that the crest would be uniformly advanced as at P_4 in the successive cases, until the wave crest has passed over a full wave length as at P_8 in the last case. If a series of views such as shown in Fig. 2 are superimposed, one over the other, in such manner that views of stationary objects, like the piles S and S_1 register over each other, then successive positions of the wave's crest and corresponding positions of the float would be brought together as shown at 1, 2, 3, etc., in Fig. 3, and lines connecting adjacent points will show the path described by the float during one full wave length.

Referring to Fig. 4, A B represents a straight line and A R is a circle tangent to A B at A. If the circle A R is rolled along the line A B in the direction indicated by the arrow W, and the distance from A to B is equal to the circumference of the rolling circle A R, then in half a revolution a point R at the extremity of the diameter A R will fall on A B at A_4 midway between A and B; in a complete revolution the point A of the circle A R will again touch the line A B at the point B and the point R would fall vertically under B. If the original semi-circle A-1-2-3-R be divided into four equal parts, A-1, 1-2, 2-3 and 3-R, and A A_4 be divided equally into the same number of spaces, then point 1 will fall on A_1 and when it does, the center of the circle will be at C_1 in the vertical line A_1 C_1, and will be similarly rotated for succeeding points of tangency A_2, A_3, etc. The point R will be carried to the positions R_1, R_2, etc., finally falling at A_4 and, continuing, will follow in the curved path A_4 R_5 R_6 R_7 R_8. By finding successive positions occupied by the point R for a large number of points of tangency, such as A_1, A_2, A_3, the continuous path is determined which would be described by the point R when the circle A R is rolled along the line A B. The curve thus described by a point in the circumference of a circle rolled along a straight line is called a "cycloid."

By extending the radius C R to a point T outside the rolling circle, successive positions of the point T can be determined, as it describes the path indicated by the dotted line for successive positions of the center of the rolling circle. This curve is called a "curtate cycloid." In the same manner one may determine the successive positions of a point P which is within the circumference of the rolling circle. This curve $P_1 P_2 P_3 \ldots P_8$ is called a "prolate cycloid." The term "trochoid" is used to denote both the curtate cycloid and the prolate cycloid, although the "trochoidal-wave theory" almost exclusively deals with properties of the prolate cycloid.

THE TROCHOIDAL MOTION.

As previously stated, the trochoidal-wave theory is based on the assumption that the profile of the surface wave is in the form of a trochoid. It can be shown, as assumed by this theory, that dynamic equilibrium is satisfied in this form of wave when the moving particles of water describe orbits which are circles whose centers are fixed with reference to the uniform movement of the wave form, and that each particle, traveling at uniform speed in its orbit, makes a complete revolution once during the passage of each complete wave.

It has been observed that these conditions are usually characteristic of natural deep-water waves, but the same general relations of wave form and motions of particles have been found to exist in artificially formed waves.

A deep-sea wave of this form may be assumed to travel over the general surface at a uniform rate of speed within its own length, although, taken as a series, oncoming waves may increase in length or height from the action of the wind or may die down into a calm. The same trochoidal conditions exist, though the properties may be different and there is reason for the belief that not only do waves take on other forms as a result of initial disturbances, but upon running out into deep water they quickly work down into the trochoidal form.

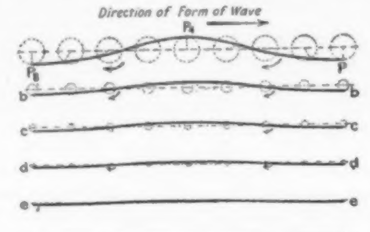


Fig. 5.—Orbit circles diminishing with increased depth.

According to the trochoidal theory, if the wave form, shown by the successive positions in Fig. 2, is an ordinary deep-water wave, then the curvature of the profiles in each case will be that of a prolate cycloid; and if the path of a particle such as P has been correctly determined, as shown by points 0, 1, 2, 3, 4, 5, 6, 7 in Fig. 3, then these points will be found to lie on the circumference of a perfect circle; and having been observed at equal intervals of time they will be equally spaced around such an orbit circle.

It is of interest to trace the geometrical relations between the wave form and the orbital motion of a particle, showing their conformity to the theory. These relations may be understood by reference to Figs. 2, 3, and 4. In position a, Fig. 2, $P_4 P$ represents the profile of a half wave length from the center of the crest to the center of the trough of the wave, the curvature of profile being drawn in the same length, height and form of trochoid as the semi-trochoid P P_1 P_2 P_3 P_4 in Fig. 4.

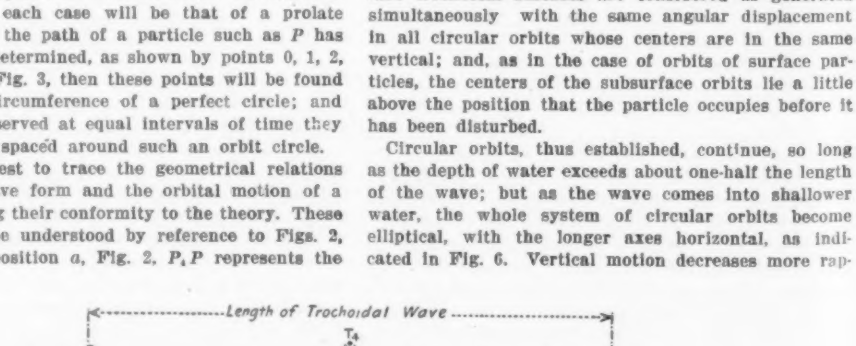


Fig. 4.—Development of the Cycloid and Trochoid.

Assuming that the horizontal direction of travel of the wave form is in the direction of the arrow V in Figs. 2 and 4, the crest for half the whole depth of the wave travels forward with the wave motion, while the surface of the trough, up to about one-half the depth, travels backward, as indicated by the small arrows. As the surface form goes forward, a surface float dropped in the trough as at P is lifted, but moved backward until it reaches half the height of the wave, as at P_2; next it is caught by the forward motion of the breast of the wave and carried forward and upward to the very top as P_4; then descending on the back of the wave, continues in a forward motion to P_5 and to P_6. In falling with the trough of the wave from the latter position it moves backward with the trough through position P_7 and then resumes position P ready to repeat the cycle.

In Fig. 2 the successive positions are of the same trochoidal form as P P_1 P_2 P_3 P_4 P_5 P_6 P_7 P_8 in Fig. 4, but each with the crest of the wave advanced one-eighth of a wave length. The relations which the circular orbit bears to the trochoidal form will be better understood from a re-examination of the construction of the trochoidal form, Fig. 4. Referring to Fig. 4, the trochoidal form P to P_4 was understood to be the curved path that would be traced by the point P being carried along with the rolling circle A R in rolling along the line A B from A to A_4. Assuming C P to be the radius of the orbital circle of a surface particle, the distance A A_1 being equal to one-eighth of the circumference of the rolling circle and equal to the arc A-1, the point 1 falls at A_1 so that when the center of the rolling circle comes into the same vertical line as A_1, the radius C P has advanced to C P_1. It is apparent, therefore, that if the center of the rolling circle and orbital circle were stationary, a revolution of one-eighth of a circumference would carry the point P up and around on the orbit circle which would be in the line P_1 J at the same elevation as P_1. As C J is parallel to C_1 P_1 the distance from P_1 to J equals the distance from C_1 to C and this is equal to one-eighth the total wave length A B. Hence, with the center of the orbital circle fixed, a horizontal movement of the trochoidal form toward P in direction of the arrow V through a distance P J would be coincident with the movement of the particle through one-eighth of its circular orbit. After being raised as high as the center of its orbit, as shown at P_2, then in rising to a higher position as P_3, the particle has a horizontal motion in the same direction as the wave, until it has again fallen to half the height of its orbit circle, as at P_6 and then falls again with the backward motion of the trough of the wave, as previously described.

To satisfy the trochoidal equilibrium of the surface, the body of water under the surface divides into an indefinite number of trochoidal subsurfaces, each of which must have been originally composed of horizontal surfaces which, by passage of the trochoidal wave, are converted into trochoidal subsurfaces. Thus, in Fig. 5 the trochoidal surface form being P_1 P_4 P_8, the original horizontal subsurface layers b, b_4 b_8, c, c_4 c_8, d, d_4 d_8, etc., become trochoidal surfaces, the orbit circles of each diminishing in diameter in geometrical progression as the depth increases in arithmetical progression. Particles at the greater depths follow the same law as the surface particles. The subsurface trochoidal surfaces are considered as generated simultaneously with the same angular displacement in all circular orbits whose centers are in the same vertical; and, as in the case of orbits of surface particles, the centers of the subsurface orbits lie a little above the position that the particle occupies before it has been disturbed.

Circular orbits, thus established, continue, so long as the depth of water exceeds about one-half the length of the wave; but as the wave comes into shallower water, the whole system of circular orbits become elliptical, with the longer axes horizontal, as indicated in Fig. 6. Vertical motion decreases more rapidly than horizontal motion at the greater depths; hence the deeper a particle is situated, the more flattened is its orbit, so that a particle in contact with the bottom simply moves forward and backward, without any vertical motion, as shown at C—C, C—C, etc., in Fig. 6.

The trochoidal curves thus developed by elliptical orbits tend to make the crest of the wave sharper. When the orbits are thus converted from a circular to an elliptical form, the time occupied by each particle in making one revolution in its flattened orbit is the same as it required in traversing its orbit in a circular form. Hence, when a series of waves advance into water gradually becoming shallower, their periods remain unchanged, but their speed and consequently the lengths of the waves diminish and their slopes become steeper. The elliptical orbits become more and more distorted, so that the breast of each wave gradually becomes steeper than its back and the advancing change of form continues as if the crest of each wave were overtaking the trough in front of it. This is indicated by the approach of *A* toward *B*; and *B* toward *C* in Fig. 7, until finally the front wave curls over beyond the vertical, its crest falls forward on the beach and breaks into surf.

The ordinary deep-sea wave, from its formation to the time it is broken up into surf, may be said to have passed through three distinct stages:

(1) The trochroidal form with circular orbits of its particles, while in water of greater depth than one-half the wave length.

(2) The trochoidal form with elliptical orbits of its particles, while in shallower water with reduced length, height and speed of wave.

(3) The shallow-water wave, with no regularity of

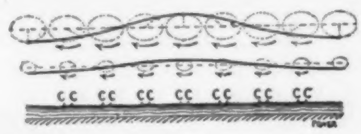


Fig. 6.—Circular Orbits changing to elliptical form in shallow water.

trochoidal form, with elliptical orbits becoming rapidly distorted and the motion of the particles following no law but accidental combinations of local circumstances of wind, tides, currents and countercurrents combined with the chance influences of irregularities of the bottom.

Once the deep-sea wave has passed beyond the second stage, no reliance can be placed on the motions that are taken up by the particles and it is equally impossible to conclude how much of the energy of the wave while in the trochoidal form has been transmitted to the final surf wave. The energy of motion of a given wave form, which advances into shallow water or through a narrow inlet, is successively communicated to smaller and smaller bodies of water and there is a tendency to throw the whole body of water into more and more violent agitation. Energy thus expended may occasionally be transmitted forward in a stated wave form, but the chance is that it is counteracted by losses of energy which take place in the formation of eddies and surge at sudden changes of depth and irregular friction of the bottom.

The dynamic principles of the trochoidal-wave theory, now so generally accepted, were first advanced by Prof. Rankine, but the credit of extending the results to formulæ of the horse-power of deep-sea waves belongs to Lieut. Stahl,* United States Navy, from which formulæ he has constructed a table of the total energy of deep-sea waves in terms of horse-power per foot of breadth for waves 25 to 400 feet long, and for ratios of lengths to heights of waves varying from 50 to 5.

In referring to this table it should be borne in mind that it is intended to express the gross theoretical horse-power resulting from computation of the combined kinetic and potential energy of deep-sea waves. For reasons already stated the full energy of the deep-sea wave cannot exist after the wave has come into shallow water. One must not overlook the fact that the wave motions in shallow water so completely neutralize each other as to obliterate the relative amount of energy obtainable in shallow water from deep-water waves of different sizes. Therefore the table of horse-powers of deep-water waves can hardly be regarded as a measure of energy resident in shallow-water waves. Hence, in construction and application, wave motors which are to be used in shallow waters depend almost entirely upon the lifting power of the waves, their height, frequency, chance circumstances of locality and weather conditions.

Any energy received from lateral motions, being the resultant of other motions which in the main tend to neutralize each other, can only occasionally produce energy suitable for transmission in the form of useful power and this with but feeble effect. The total energy obtainable as power from shallow-water waves per foot of shore line can, therefore, be but a small fractional part of the energy per foot of breadth of the deep-sea waves out of which the shallow-water waves originate and the power derivable from shallow-water waves is practically confined to the utilization of their lifting power. This statement applies most particularly to wave motions in waters where, from shallowness or irregularities of the bottom or other causes peculiar to the location, the trochoidal orbital motion has disappeared.

The proportion of original kinetic energy which may have passed into potential energy and which is available as lifting power will vary with different locations and will be variable for a given location. Nothing can be predicted generally of the lifting power which can be realized under these conditions. In determining the feasibility of installing a wave motor in waters of this kind, conditions peculiar to the locality should be studied separately. Observations of the site should extend over a number of seasons.

There are some locations where the orbital characteristics of the deep-sea wave continue on into waters that are shallow enough for establishing wave motors. This may be at depths of 20 to 40 feet where, as illustrated in Fig. 6, the upper trochoidal layers have had their circular orbits of the deep-water wave converted into elliptical orbits and most of the orbital energy of the deep-water wave may be regarded as continuing in the elliptical orbits. It has been proposed to utilize this orbital energy by intercepting the "to and fro" motion of the "distorted verticals."

One of the main difficulties attending this proposition would seem to lie in the fact that in depths where it would be reasonable to erect and maintain wave motors, a large proportion of the original deep-water orbital energy is at or near the bottom and the upper trochoidal layers have only about the same orbital energy which they had before the orbits passed from circular to elliptical forms. Under these circumstances, an intercepter of the orbital energy, in the form of a "paddle" or other resisting surface, would have to be hinged at its lower end, or be guided in some manner causing it to move parallel with the motion of the wave. In either case, it is difficult to conceive of a mechanism by which more than about one-half of the orbital energy of the wave could be thus intercepted, even though the direction of waves were constant.

Mathematical discussion of the energy of the complete trochoidal wave goes to show that one-half of the total energy is kinetic and one-half potential. Hence not more than one-fourth of the total wave energy per foot breadth of wave could in any probability be opposed by mechanism designed to receive the kinetic energy of subsurface particles. Undoubtedly the most efficient form of surface for thus receiving the kinetic energy would be plane surfaces placed normal to the motion of the wave and moving with it; hence if constrained to operate on fixed guides or to swing on fixed pivots they would lose orbital energy for any change of direction in the travel of the waves.

There are two additional considerations: Efficiency of the surface for receiving the kinetic wave energy and efficiency of the mechanism for conversion of the effect into useful power. As to the former, it is generally conceded by hydraulic engineers that the kinetic energy of a current, received on a submerged surface varies according to no known law for a given depth of submergence, velocity of current and size or form of surface; the efficiency has to be determined by experiment for each particular case. At best, the great-

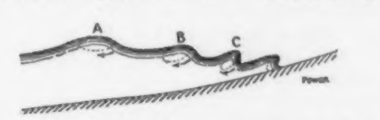


Fig. 7.—Elliptical Orbits distorted on sloping beach.

est energy to be derived is from the surface particles or those at very moderate depths of submergence, traveling at uniform velocity, and by plane resisting surfaces placed normal to the current and traveling with the current at half of its velocity. Poncelet determined that with plane surfaces submerged and moving in this manner he could realize 40 per cent of the kinetic energy of the intercepted current.

Applying this to the interception of one-half of the kinetic energy of the wave, under most favorable circumstances only 20 per cent of the kinetic energy of the wave for propelling the intercepting surface would be realized. Any rugged form of apparatus likely to be adapted for a wave motor could hardly be expected to convert more than three-fourths of this energy into useful power; that is, not over 15 per cent of the kinetic energy of the wave. Hence, with means for harmonious absorption of kinetic energy, no more than 7½ per cent of the total energy of the trochoidal wave can, in any probability, be utilized. The chances of obtaining power from "distorted verticals" are therefore founded on a very narrow margin which is much too small for commercial encouragement in the development of wave motors designed to obtain power from subsurface energy. It must be concluded that the feasibility of obtaining power from ocean waves is practically limited to their lifting power, but, in any event, the power available per foot of shore line will depend upon peculiarities of the location and weather conditions.

* *Transactions*, American Society of Chemical Engineers, vol. xiii., p. 438.

Prejudice and Sense Deception

How the Evidence of Our Senses Misleads Us

By P. Altpeter

When we see the fiery ball of the sun apparently sinking below the western horizon or rising in the east, the sinking or rising appears so evident that we cannot be surprised that humanity persisted in this error for thousands of years. We now know that it is an error. It is not the sun that moves, but the earth that rotates and carries us with it. This error, however, is not a sense deception, as is often assumed, but rather a prejudice, as the following considerations will show. If, at sunrise, we look directly at the lower edge of the sun's disk, at the moment when it touches the horizon, our eyes do not have to make any movement to pass from the sun's disk to the horizon, because there is no interval between these. If we look again five minutes later, we observe that there is an interval between the horizon and the sun. In this case the eye has to move in order to glance from the lower edge of the disk to the horizon. (Fig. 1.) From this movement of the eye we form, though quite unconsciously, the conclusion that the sun has moved. That this conclusion is false can be easily proved by laying two coins in contact with each other and then separating them about half an inch while another person turns his back to the table. If now this person, instead of making a guess, endeavors to express his real judgment, he can only say that the two coins are not now in contact, but that he is unable to tell which coin has been moved, in the absence of any mark of reference on the table. The interval between the coins could have been produced by moving the first coin, the second coin, or both. If, however, a fixed mark is made on the table, in contact with each of the coins, it is easy to see which coin has been moved. Strictly speaking, the person does not "see" this, because he stood with his back to the table during the movement, but he judges from the position of the coins with respect to the fixed marks that this or the other coin has been moved. The case of the sun and the horizon is precisely similar. When we see that they are no longer in contact, we are entitled to conclude only this: either the sun has risen or the horizon has sunk, or both of these things have occurred. He who decides differently makes a false judgment, for we have no immovable mark of reference in the sky or on the horizon. Even if a fixed star is seen at the horizon, our judgment must be the same, because we do not know from this observation whether the star is really fixed or not. To all appearance it is not fixed.

The false judgment would not have been made if the rotation of the earth were as perceptible as the movement of a wagon which is carrying us over a rough road. We infer from the vibration of the wagon that it is moving forward. If we are sitting in a railway carriage which moves so smoothly that we feel no vibration, cars at rest on the adjoining track appear to be in motion until we look at their wheels and observe that these do not rotate. Then we recognize our error, the so-called illusion instantly vanishes, and we feel that we ourselves are in motion.

By long practice one can learn to see the horizon sink at sunrise and rise at sunset. Obviously this is also a false judgment, although it happens to correspond with the truth, as we know from other observations. For, from the mere observation of sunrise and sunset, no

correct conclusion concerning the actual movement of the sun, can legitimately be drawn.

The following is another example of prejudice: I awake in the night and see a big fat man peering over the foot of my bed and two great hands grasping the bedposts. At first the apparition is somewhat indistinct, but it gradually assumes so natural an appearance that I

Fig. 1—The Horizon at Sunrise and 5 Minutes Later.

cannot decide whether it is a specter or a reality, even after many minutes' observation. A nervous and timid person would be firmly convinced that there was an intruder in the room. The apparition vanishes on striking a match, but when the light goes out and the eyes are opened, after having been closed for a short time, the fat man with his fat face and big fists appears again. I attempt to seize one of the hands, and the apparition is immediately explained. The white fat hand has been

Fig. 2.—The equal lines *a* and *b* Appear Unequal.

conjured by the imagination from a spot of moonlight on the wall, the other hand was the white lampshade, standing on the table, and the head and body were represented by the window curtain illuminated by the moonlight. In this way apparitions can be explained by natural causes. Touch a ghost and it flees from you.

Here is a third example: A conjurer announces that he will cause a coin to pass through the table. He borrows a coin, which is marked with a knife or a pencil for the purpose of identification. He then wraps the coin in a handkerchief in such a manner that its form is visible from a distance, and the spectators are allowed to feel that the coin is still there. The magic wand waves, and the coin apparently passes through the table and falls into the right hand of the conjurer, who, with his left hand holds the handkerchief by one corner, high in the air to show that the coin is no longer there. In this case the prejudice lies in the fact that the spectators believe everything that is announced in imposing language. When the conjurer says, "I put the coin into the handkerchief," the spectators believe him; but,

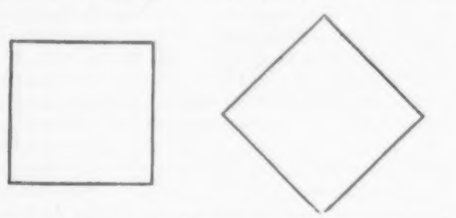


Fig. 3.—A Square standing on its corner appears larger than an equal square standing on its base.

as a matter of fact, he conceals the coin in his right hand. A similar coin has previously been sewed up in a corner of the handkerchief, so that it cannot fall out when the handkerchief is lifted. No conjurer permits a thorough examination of his apparatus, though he pretends to do so, and the attention of the observers is distracted by pompous and sonorous language. The whole art of conjuring is based upon the prejudice of the spectator.

The case of the so-called illusions of other senses is similar. A word, a sound, a noise is heard at night. The less distinctly the sound is heard, the more likely is it to be wrongly interpreted, especially when an uncanny impression is produced by the environment—a lonely road, a dark forest, a ruined tower, or a graveyard. The

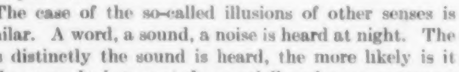


Fig. 4.—The divided line *b* appears shorter than the equal undivided line *a*

myth of the wild huntsman finds its explanation in such interpretations of the voices of nocturnal birds or animals, the sound of the wind, etc.

The perceptions of smell, taste, and hearing are also, though less frequently, liable to false interpretation. In all of these cases there is a conscious or unconscious judgment, which is formed before the perception has been thoroughly investigated and which, therefore, is a prejudice. It is a prejudice to infer the character of a man from his external appearance alone, or to infer the age of a horse from his teeth, which may have been sophisticated.

A prejudice, then, is a judgment which is made before the matter has been thoroughly investigated. It may be conscious or unconscious. It may be correct; but is more frequently false. The false interpretation of a percept of sense is called an illusion.

Are there, then, no real sense deceptions, in which our senses actually show us things otherwise than they exist in reality? Some persons see men, animals, and other objects which do not exist, or they hear noises, musical tones, words, or whole sentences which are heard by no one else, or they find a bitter or sweet taste in everything, or they are always smelling onions, etc. Such persons are firmly convinced that their apparent perceptions represent the truth. These are persons with "fixed ideas," or they are victims of disease of certain parts of the brain or the spinal cord.

Our sense perceptions are specific, i.e., each sense has

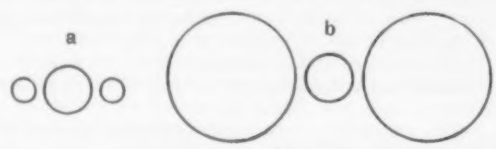


Fig. 5.—The circle *a* between smaller circles appears larger than the equal circle *b* between larger circles.

its own language, in which alone it speaks to us when its specific nerves are stimulated. The optic nerve responds with a luminous sensation, whether it is stimulated by light, by pressure, by electricity, or by congestion or inflammation. The auditory nerve is stimulated not only by sound waves, but also, as in the familiar buzzing and ringing in the ears, by abnormal blood pressure and other causes. The same is true of the other nerves of sense. The nerves of feeling are affected both by touch or pressure, and by heat or cold, as in toothache. Each nerve has its own peculiar speech, but also its own peculiar sensitiveness. Although the hallucinations of the insane are not caused by any external object or stimulus, it is not impossible, indeed, it is very probable, that morbid processes inside the body (inflammation, ulceration, congestion, etc.) stimulate the nerves of sense, calling forth sensations or perceptions which are wrongly interpreted and assigned to external causes. The difference between an illusion and a hallucination is that the former is produced by an external cause and the latter is not.

Can a true sense deception occur in the case of a sane person? When I swing a burning coal in a circle, I see a circle of light which has no real existence. If I spin round rapidly and then stand still, "everything goes round," but only for me. Sitting in an express train, I see telegraph poles and other objects flying past me. A man seen through a fog appears of gigantic stature. The sun and moon appear much larger when rising and setting than when they are high in the sky. These appearances do not correspond to reality. Are they, therefore, sense deceptions?

The height of a square appears greater than its width; a line divided into several parts appears longer than an equally long but undivided line, and a distant object appears smaller than a near object. All of these things are due to the fact that we unconsciously measure distance by the time occupied by the eye in traversing that distance. If this time is prolonged or diminished

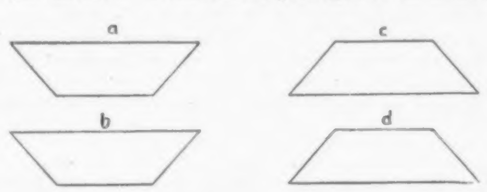


Fig. 6.—All of these figures are equal but *b* and *c* appear larger than *a* and *d*.

by any cause, the distance or the length of the object appears greater or smaller.

We recognize distance and motion, not by sight, but by feeling. Sight and hearing are commonly regarded as the most important senses, but this is a great error. The most important sense is the sense of feeling, without which we would have no preception of distance or motion, and could not even walk a step. That an extensive view and a high degree of education can be attained without either sight or hearing is proved by the history of Helen Keller, who could never have reached this stage without the sense of feeling, even with perfect sight and hearing.

If the line *a* (Fig. 2) appears shorter than the equally long line *b*, the eye is not at fault. In glancing over the line *b* the eye is induced to go a little further by the oblique terminal lines, while in the case of the line *a* these lines have the opposite effect. As the eye moves a shorter distance, the line *a* is inferred to be shorter than *b*.

A square which stands on one of its corners appears larger than an equally large square which stands upon its base (Fig. 3) because in the former case the eye glances over the diagonals and in the latter over the sides.

The undivided line *a* (Fig. 4) appears longer than the equally long bisected line *b*, because in the former case the eye sweeps over the whole line, while in the latter it sweeps over the halves separately. A giant and a dwarf standing side by side appear respectively smaller and shorter than they would if seen separately. The area of a surface is overestimated when near smaller areas and underestimated when near larger areas. The circles *a* and *b* (Fig. 5) are equal, but *a* appears larger than *b* because *a* is placed between two smaller circles and *b* between two larger circles.

In Fig. 6 the areas *b* and *c* appear larger than *a* and *d*. This illusion is heightened by the natural tendency to regard the figures as representing hollow dishes which fit inside each other. The farther from the eye the figures are held, the more striking becomes the illusion. When the hand is dipped first into warm and then into moderately cool water, the latter appears very cold, owing to the effect of contrast.

A white area appears larger than a dark area of equal size. (Fig. 7). The rays of light which form the image of the white object upon the retina stimulate the nerves a little beyond the border of the image, hence the impression is that of a larger object, while a dark object surrounded by a white area is apparently diminished for the same reason. This phenomenon is known as irradiation.

It is not the fault of the ear that the sound of a bell continues to be heard for a time after it is struck, nor the fault of the eye that a revolving light appears like a circle of fire.

Through blue spectacles everything looks blue and therefore unreal, but no one would assert that we are

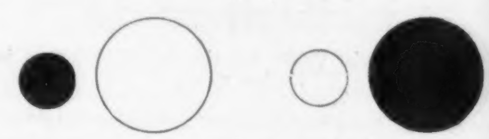


Fig. 7.—A white area appears larger than an equal black area.

deceived by the spectacles. If the transparent part of the retina were colored blue or red, however, we would believe that all objects were blue or red. Objects appear differently by sunlight than by torchlight. If the earth's distance from the sun were increased tenfold, the appearance of all objects would be greatly changed. It is a prejudice to believe that we perceive things as they are in reality. Our organs of sense are imperfect. They do not show us all properties of objects, but we cannot for this reason assert that they deceive us.

There are curved mirrors which make our faces appear long and narrow or short and broad, but no one asserts that these mirrors deceive us.

When we are photographed and receive a dozen prints, this is no less a "deception" than the doubling of objects as seen by some persons. It would be a prejudice to believe that every picture must represent a different object.

A color-blind person fails to perceive one or more colors; instead of them, he sees only gray. The cause lies in the constitution of the layer of the retina, which consists of microscopically small rods and cones, by which sensations of light and color are produced. If a certain part of the cones is wanting, the sensation of the corresponding color is wanting also. We know, too, that some nocturnal animals, such as owls and bats, are destitute of the layer of cones and are, therefore, color-blind. A blind man who sees nothing whatever is no more deceived by his eyes than the color-blind man who sees only partially. Even the normal eye cannot perceive ultra-violet rays, and we have no organ of sense for electric rays. In the words of Kant, "Our senses do not deceive us; not because they always judge correctly, but because they do not judge at all."
—*Kosmos.*

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